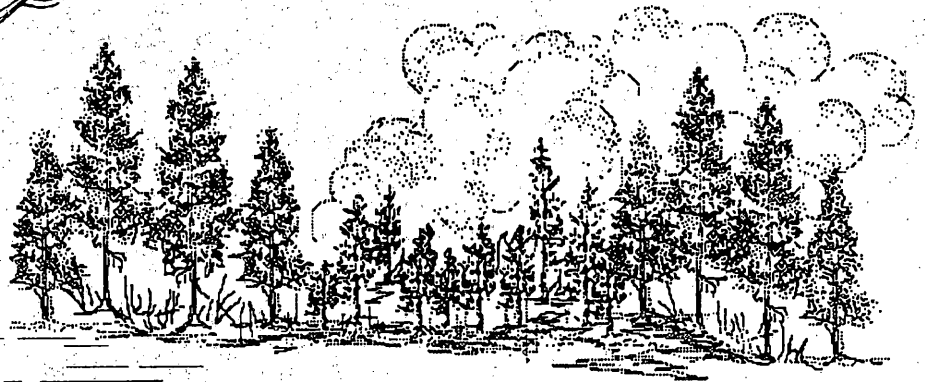


Andrew

Report of the Task Force on Prescribed Fire Management Criteria



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on
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**REPORT
OF
THE TASK FORCE ON PRESCRIBED FIRE MANAGEMENT CRITERIA**

EXECUTIVE SUMMARY

The Prescribed Fire Management Criteria Task Force was established in September of 1988 to review policy, direction, guidance, criteria, and processes used in managing prescribed fire programs, particularly prescribed natural fire, to determine adequacy or need for revision. The objective of the Task Force was to develop specific recommendations for improving procedures used in managing prescribed fire programs at the National, Regional and Forest level.

The Task Force consists of eight members representing a cross-section of wilderness and fire managers with a broad perspective of the Forest Service, both organizationally and geographically.

The Task Force held its initial meeting in November 1988 and decided at this meeting to concentrate on prescribed natural fire in its review and recommendations. An extensive list of issues to be addressed and resolved was identified and categorized into four subject areas: Program Management - Program level action/direction that influences planning, decisions, management and funding of prescribed natural fire; Plans - Planning inter-relationships from Forest Plans to implementing prescribed natural fire programs; Analysis and Decisions - Make "good" decisions, beginning with the initial decision to declare a natural ignition a prescribed natural fire, as well as decisions during the management phase; Management Phase - Actions and decisions made after a natural ignition is declared a prescribed natural fire.

The Task Force found that, for the most part, direction and procedures for implementing a successful prescribed natural fire program are already in place. The following recommendations are directed at improving shortcomings in current direction and procedures.

The Task Force recommends that:

1. Research and development activities for prescribed natural fire management be given high priority.
2. Forest Service Manual 5140 be revised to address the requirements of a prescribed natural fire program.
3. Forest Service Manual 5140 be revised to specify elements required for a prescribed natural fire program and identify minimum criteria to be used in the initial "go/no go" decision process and subsequent management phase decisions.
4. Forest Service Manual 5140 be revised to require joint/coordinated plans where prescribed natural fire programs involve multiple planning, administrative, and agency boundaries.

5. Forest Service Manual 5140 be revised to include knowledge and skills standards necessary for prescribed natural fire and wilderness fire management.
6. Contingency planning related to prescribed natural fire programs be strengthened.
7. Prescribed fire elements of the Fire Management Action Plan be strengthened to give an adequate description of the prescribed natural fire program.
8. Knowledge and skills necessary to implement and manage a prescribed natural fire program be identified, an inventory of current capability to meet those needs be conducted, and standardized training to meet these knowledge and skill levels be developed.
9. The role of a management ignited prescribed fire program within or adjacent to wilderness boundaries or inholdings be assessed and implemented where feasible and appropriate.
10. Regions develop a program to ensure cross training in wilderness and fire management between both functional activities.
11. A National level effort be initiated to address and clarify the objectives and planning process for prescribed natural fire, both within and outside wilderness.
12. Training courses addressing prescribed natural fire decisions include risk assessment and potential outcome instruction.
13. Funding for prescribed natural fire programs be strengthened.
14. Direction be provided on the appropriateness of installation and use of weather instrumentation and acceptable fire management impacts associated with prescribed natural fire in wilderness.
15. A national educational video on the Forest Service's prescribed natural fire program be developed.
16. A follow-up Task Force be chartered to review the status and effectiveness of revisions in policy and direction resulting from implementation of recommendations of the Secretarial level Fire Management Policy Review Team and the Prescribed Fire Management Criteria Task Force.

REPORT OF THE TASK FORCE ON PRESCRIBED FIRE MANAGEMENT CRITERIA

INTRODUCTION

The Prescribed Fire Management Criteria Task Force was established in September of 1988 to review current written policy, direction, guidance, criteria, and processes used in managing prescribed fire programs, particularly prescribed natural fire, to determine adequacy and/or need for revision. The objective of the Task Force was to develop specific recommendations for improving procedures used in managing prescribed fire programs at the National, Regional and Forest level. The Task Force is composed of fire and wilderness managers with perspectives from all levels of the Forest Service and all regions of the country. A listing of Task Force members is included as Appendix A.

Shortly after establishment of the Task Force, the multi-agency Fire Management Policy Review Team came into being in response to the extraordinary fire season of 1988 in the western United States. In December, the Interagency Team reported to the Secretaries of Agriculture and Interior on recommendations to improve fire management policy in national parks and wilderness. Many of the actions recommended in this report on prescribed fire management are directly responsive to, and complement, recommendations in the interagency report.

In November 1988 the Task Force held its initial organizational meeting. At this meeting the decision was made to concentrate on prescribed natural fire in this report. An extensive list of issues to be addressed and resolved was identified. It was found that many of the issues changed in character as one looked at them from different aspects of the prescribed natural fire program (e.g., planning phase vs. management phase of a prescribed natural fire). As a result, the Task Force organized and addressed issues in the following categories: **PROGRAM MANAGEMENT** - Program level action/direction that influences planning, decisions, management and funding of prescribed natural fire; **PLANS** - Planning inter-relationships from Forest Plans to implementing prescribed natural fire programs; **DECISION MAKING** - Making "good" decisions, beginning with the initial decision to declare a natural ignition a prescribed natural fire, as well as decisions during the management phase; **MANAGEMENT PHASE** - All actions and decisions made after a natural ignition is declared a prescribed natural fire.

The discussion of issues is organized in the body of this report by these categories.

Before going further, the term prescribed natural fire needs to be defined. There are two kinds of wildland fire, wildfire and prescribed fire. Wildfires may result from natural causes (lightning) or human causes (arson, accidental escape). Wildfires are suppressed in the most efficient manner appropriate for each individual situation. Prescribed fire is a pre-planned management action to use fire as a tool to achieve defined land

and resource management objectives. A prescribed fire may be ignited by qualified fire managers acting within the direction of an approved prescribed fire plan which establishes weather, fuel conditions, fire behavior, and resources (people, equipment, and finances) necessary to maintain the fire within defined parameters to achieve stated objectives. A natural ignition such as a lightning fire may be managed as a prescribed natural fire under similar circumstances defined in an approved fire management plan, or Fire Management Action Plan approved by the Regional Forester. Natural occurring ignitions managed as prescribed fires are called prescribed natural fires.

A prescribed fire, either natural or management ignited, is determined to be a wildfire if conditions become such that the fire exceeds, or is projected to exceed, the pre-defined parameters. Once classified as a wildfire, it remains a wildfire until extinguished.

Early on, the Task Force began to focus on the relationship between managing prescribed natural fire and the wilderness program. Wilderness is defined by Congress to be a place "managed so as to preserve its natural condition and which ...generally appears to have been affected primarily by the forces of nature, with the imprint of man substantially unnoticed". Fire is a major natural force in some wildernesses and policy/direction regarding prescribed natural fire will have direct implications on wilderness management programs. There are 354 Wildernesses managed by the Forest Service, less than 10 percent of which have approved fire management plans. An early observation of the Task Force was that wilderness program managers must take a more active role as champions for prescribed natural fire in wilderness if wilderness management objectives are to be met.

Although this Report focuses heavily on prescribed natural fire within wilderness, it is important to emphasize that implementation of the recommendations contained herein are also applicable to prescribed natural fire outside wilderness.

It is essential that strong partnerships between wilderness/recreation, fire and other affected resource staff units be developed and maintained. The wilderness manager must establish wilderness management objectives, develop guidelines, and define limitations to the fire management program based on these management objectives. Fire management provides the support organization to implement those resource management objectives and will also define program limitations based on operational capability and resource availability. Jointly, the two define total program capability.

Defining success in a prescribed natural fire program is very important because it differs from how success is defined in the wildfire suppression program. Success in wildfire management is generally the same in all situations "least cost/least loss". In prescribed natural fire management, success is defined in each plan in terms of benefits from fire. The number of acres burned may be interpreted as a loss in the wildfire suppression program while it may well be a measure of success in the prescribed natural fire program. It is not appropriate to assume that a person trained in suppressing wildfires is automatically qualified to manage a prescribed natural fire. While many of the skills and techniques are similar, the differing value systems for success can cause problems.

It is appropriate to discuss success in terms of existing prescribed natural fire programs. There are excellent examples of wilderness fire management programs that have been successful in meeting a variety of wilderness and fire management objectives since the 1970's. These successful programs were examined in order to identify common characteristics that might be used to direct future prescribed natural fire managers in the direction of success. The Task Force recommendations reflect many of these common elements.

Another measure of success is reflected in rewards or incentives for executing a desirable action. In examining the prescribed natural fire program it was found that the risks can be great and failures often publicly ridiculed. The successes far outnumber the failures, but rewards currently appear to be personal with "success" often not appreciated internally or by the general public. A prescribed natural fire program is identified with programs that have historically received very limited project funding. The incentive is to avoid

the prescribed natural fire program and declare natural ignitions as wildfires. Suppression of some wildfires in wilderness through use of a confinement strategy may have essentially the same result as a prescribed natural fire, at the expense of emergency Fighting Forest Fires (FFF) funds, and with less perceived "risk".

The Task Force found that direction and procedures for implementing a successful prescribed natural fire program are, for the most part, already in place. This review is timely in that the Forest Service has been operating under the existing direction for several years and now has the opportunity to make improvements based on past experiences. Where weaknesses in current direction/procedures were found, recommendations for improvement were developed. The true measure of success, however, is performance, as exhibited in results obtained from proper execution of the program. No matter how good the direction, it is of little value if there is poor execution. Development and execution of prescribed natural fire management actions must be carefully monitored at all levels of the organization to ensure that highest standards are met in a program which carries an inherent risk not common to other Forest Service programs.

The Forest Service must be prepared to accept a certain level of risk inherent with a prescribed natural fire program. No matter how well the job is done in developing and implementing prescribed natural fire management actions, there is always the chance that a prescribed fire could become a wildfire because of unpredictable circumstances beyond the manager's control. When this occurs fire managers must have the assurance that the organization will stand behind them as long as they have followed policies and procedures.

PROGRAM MANAGEMENT

The Task Force addressed six areas related to management of prescribed natural fire programs where issues had been identified. These were: responsibility, success, management ignited prescribed fires versus prescribed natural fires, regional involvement, staffing and resources commitment, and funding.

Responsibility - Generally, the staff responsibility for all phases of fire management in wilderness resides within the unit's fire management organization. In almost all cases, fire management personnel had key involvement during the planning phase, as well as continuing to handle the day to day activities in managing the fire program.

Recreation/wilderness manager's involvement is demonstrated in different ways. On some units they handle the public involvement, training, provide funds, coordinate with users, provide information to prescribed fire managers on safety and use, and serve on monitoring teams.

Wilderness management, including input into the standards and guides for fire management, is the responsibility of wilderness managers. Fire managers provide the support organization to implement the fire management direction within wilderness. The most important thing is not who does what job, but how well wilderness managers and fire managers coordinate. The most successful programs are those where line officers, wilderness staff, fire staff, and other affected resource staffs are all working toward common objectives and coordinating at each administrative level.

Success - There has been considerable discussion on how to define a successful prescribed natural fire program in any given wilderness. In discussions with a number of field personnel, it was refreshing to hear the response, "a program that meets the objectives as outlined in the Forest Land Management Plan (FLMP)." This in itself, however, could be a problem if FLMP's have not been approved, or if there was inadequate public involvement in developing the FLMP or other approval document authorizing the wilderness fire program.

A common theme when viewing success is that the program must be acceptable to the public. The acceptance must be at the level that the public will not voice objections to the point of stopping the program. This is labeled management by consent.

There is also the possibility of conflict between what the wilderness manager views as success and what the fire manager sees as success. The wilderness manager may view a prescribed natural fire successful as long as it is allowed to play its natural role without resulting in major control problems, while the fire manager might consider the same fire unsuccessful because of the demand for resources, etc. to manage and/or keep it within prescription.

Management ignited prescribed fire versus prescribed natural fire - The Task Force addressed how individuals view the difference in the decisions and risks associated with management ignited fires versus natural fires.

Generally, field personnel feel that decisions are easier to make with management ignited fires. Decision makers feel more in control of the situation with management ignited fires because they can decide when, where, and how ignition occurs, and because of the shorter time frame involved.

Risk can be significantly different between management ignited fires and natural fires. With natural fires there are more variables that are beyond the control of the decision maker. With management ignited fires, the location, time, funding, prescription, time frame, available resources, weather, size and transportation are all easier to deal with. The level of risks of a prescribed natural fire program are affected by the level of acceptable activity in such areas as mop-up, holding actions, disturbance of land surface, alteration of the wilderness landscape, duration of the fire, etc.

There is a role for a management ignited prescribed fire program within or adjacent to wilderness boundaries or inholdings where current fuel conditions and hazards prevent managers from utilizing prescribed natural fire successfully. Implementation of a management ignited prescribed fire program in these areas, under the authority currently provided in Forest Service Manual 2324.21, would enhance the fire manager's capability to implement and manage a prescribed natural fire program. It would also reduce the risks of damages or losses associated with a prescribed natural fire program.

Regional involvement - Presently, Regional Office fire organizations are involved in prescribed natural fire programs at varying levels. Descriptive terms range from, "not much", to "very supportive", to "heavy involvement". Generally, Forest personnel felt that Regional Office involvement was adequate, although there were suggestions for improvement. Suggestions included: more assistance with public involvement; assistance in telling success stories; higher priority for funding of the program; more Regional and National monitoring of status of fires and overall situation; advice on allowing new starts to be declared prescribed natural fires; leadership in setting priorities on scarce resources; and providing direction to assure more consistency amongst wilderness fire plans.

When determining the level of involvement of recreation/wilderness organizations, the issue is not nearly so clear. Some thought the support and leadership for the program was good, but others thought the support was non-existent.

Staffing and Resources Commitment - Generally, field units believe that staffing levels are okay when activity is low to moderate. However, the depth of experienced managers and fire behavior skills is such that when there is a lot of activity, either locally and/or nationally, available resources are exhausted very soon. In dealing with a prescribed natural fire the decision is very easy because of the way prescriptions are written, i.e., availability of resources is a "go/no go" decision criteria. As a result, the prescribed natural fire program has required some program managers, prescribed fire managers, and other skilled resources to be unavailable for wildfire mobilization during ongoing prescribed natural fires. While on the other hand, in some cases, these resources have been reassigned from prescribed natural fire projects to wildfire suppression efforts at the expense of the former.

There is competition for resources between the prescribed natural fire program and the suppression organization, and as suppression activity increases, the competition increases, and the decisions are more complicated. On many units the same individuals are involved with three activities, i.e., wildfire suppression, management ignited prescribed fire, and prescribed natural fire. This holds true also for other support personnel and equipment. Once ignition has occurred and the fire is designated as a prescribed natural fire, there must be equal importance placed on the assignment of resources to it as there is to wildfire.

Under the present situation, funding may be more important than resources. It is viewed that funding drives the prescribed natural fire program, i.e., availability of funding is a "go/no go" decision criteria. The need for significant resources to be pulled from a prescribed natural fire may well dictate it being declared "out of prescription" and declared a wildfire. In many cases, the same number of resources may be utilized regardless of the classification of the fire, and the end result may be essentially the same - the issue is one of priorities.

There currently are problems with the way the Interagency Situation Report is being used. Block 3 - Contingency Level, is intended for Regions to report the number of units in "Level II" and "Level III". The levels referred to are contingency levels as described in Forest Service Manual 5121.2 and not planning levels as listed in the National Interagency Fire Coordination Center Mobilization Plan. An additional problem is that only the Forest Service uses these levels and many Regions are not reporting on a regular basis.

Block 4 - Prescribed Fire Section, is reported by the Forest Service only and does not portray the overall story of other interagency cooperator activity. The reported numbers do not indicate the complexity of the situation, nor give an idea on how many resources may be committed to prescribed fires.

Funding - Funding has been identified as a barrier in meeting the objectives of fire management in wilderness. The objectives being (FSM 2324.21):

1. Permit lightning-caused fires to play, as nearly as possible, their natural ecological role within wilderness.
2. Reduce, to an acceptable level, the risks and consequences of wildfire within wilderness or escaping from wilderness.

The lack of adequate funding set up to manage a prescribed natural fire program may be a barrier. When funding a prescribed natural fire program in wilderness, the method of funding varies by Region and Forest. Units use National Forest Aviation and Fire (NFAF) funds, National Forest Recreation (NFRN) funds, National Forest Wildlife and Fish (NFWF) funds, or a combination of these depending upon the functional benefits received. In some cases funds are set up to manage a small or very moderate program, anticipating no problems or no resource requirements beyond that needed for monitoring. This limited funding, however, may require changing the status of a prescribed natural fire to wildfire for the sole reason project funds are not available to manage the fire throughout its entirety.

The concern here is not one of declaring a prescribed natural fire a wildfire when it is "out-of-prescription", but rather a concern with declaring it "out-of-prescription" simply because of unavailability of funds or limited funds, even though the fire is meeting wilderness and fire management objectives. The problem is one of priorities in planning and funding the prescribed natural fire program, including available funding to manage a more complex situation when it occurs.

Funding of a prescribed natural fire program in areas outside of wilderness may be less complicated than inside wilderness because the benefits are usually associated with a funded and accountable target within the Management Attainment Reporting System (MARS).

PLANS

The basic task was to review the Forest Land Management Planning (FLMP) process and seek weaknesses or inconsistencies which could lead to shortcomings in the prescribed natural fire program. An analysis of each item is presented here.

Review Forest Service Manual(FSM) direction and instructions to ensure that:

- Specific functional direction agrees between fire and wilderness.

Basic direction agrees in the Manual and in the FLMP process. The differences occur when a person or program area takes the lead in developing FLMP direction independently rather than in an inter-disciplinary approach. Forests were found where fire managers were perfectly willing to set wildfire suppression direction without the presence of clear wilderness management objectives and vice-versa. Wilderness management planning is not set forth clearly as a concept for all to understand without a true inter-disciplinary approach. The role and objectives of wilderness fire management is even less well defined.

- Role of prescribed natural fire is clearly defined in Fire Management Action Plans (FMAP).

The FMAP is the implementation document for fire management in the FLMP process. Generally, FSM direction does not address in depth the role of prescribed natural fire in the FMAP. Some FMAP direction deals only with listing prescribed fire plans. FMAP direction at the national level leaves a great deal of latitude for this specific topic.

- The relationship of Wilderness Implementation Schedules to FMAP's, Implementation Plans and FLMP's is adequately defined.

The major problem identified here was the need to determine appropriate standards and guides (S&G's) in the FLMP process. Many FMAP's reviewed had S&G's in them rather than in the FLMP. There is a lack of consistency from Region to Region in direction over what belongs in a Wilderness Plan, FMAP, FLMP, and a Wilderness Fire Plan. Wilderness fire planning appears in different documents with little consistency, even within a Region.

- The relationship of interim plans that currently exist to other plans is clearly defined.

This turned out to be the least significant problem reviewed. Perhaps the most significant factor here is that direction concerning interim plans is out of date. Interim plans are valid only until FLMP's are approved. Interim plans must be replaced by the FMAP.

- The role of prescribed natural fire management is clearly defined in FLMP's.

Prescribed fire in FLMP's varied from too detailed to inadequate. There is a tendency to be very "result oriented" anchored by hard numbers, rather than "objective oriented" with adequate standards and guides. A consistent trait in FLMP's is that escaped prescribed natural fires consistently revert to an assessment by an Escaped Fire Situation Analysis (EFSA), or are assigned to the suppression organization for assessment. The FLMP's do not deal with these escapes other than to state the need for an EFSA. The analysis of using project funds and forces to return the fire to prescription needs emphasis. In prescribed natural fire planning there is very little discussion on "maximums", or "how much is enough".

Define the minimum standard components in the FMAP necessary to deal with prescribed natural fire management.

The findings in this section are consistent in many Regions/Forests.

- Objective setting is inadequate.
- Resource protection measures are not used as standard components while "control" parameters are. Prescribed natural fire is treated as a wildfire problem in the prescription process.
- Guides selected to measure objectives or parameters are often unique to a FLMP and not standardized across jurisdictional boundaries.
- Little attention to time of year or intensity of prescribed natural fires was found.
- Historical severity/drought analysis is superficial.

"Timely decisions" on wildfire versus prescribed natural fire determination.

The concept of timely decisions is not addressed adequately in the FSM at the Regional level and in most FLMPs and FMAP's. Lag time in decision making is adequately documented in fire season reviews of 1987 and 1988. The problems are jurisdictional and interdisciplinary and too often occur too late to be a "timely" decision. Not enough pre-planning is occurring. Fires are actually held in "limbo", jeopardizing the most cost effective suppression action when called for.

Build contingency actions into FMAP's, as well as in prescribed natural fire plans.

This does not occur consistently in FMAP's, and quite often not at all. Contingency plans show up consistently in prescribed natural fire plans but are project oriented and do not often look at synergistic effects at Forest/Regional/National level activity. There are seldom any revalidation standards/measures and "triggers" based on number of fires or acres burning at one time are rare.

ANALYSIS AND DECISIONS

The Task Force reviewed a number of wilderness fire management plans and discussed the shortcomings of the decision process and risk analyses in these plans. Some plans were weak in process, some were weak in the criteria used to make prescribed natural fire decisions, and some were weak in analyzing the risks associated with the decision at hand. In fact, however, many prescribed natural fire operations have adequate risk analysis conducted, but are apparently not well documented.

Decision analysis and risk assessment are different ways of saying the same thing. A good decision is one which is made with full consideration of the consequences of all outcomes in relation to the objectives. Simply put, good decisions:

- Clearly portray the objectives (decision criteria) of the decision maker.
- Display the risks and tradeoffs of alternative courses of action for the decision maker
 - These include the chances and values of gain and loss associated with uncertain outcomes, as well as certain outcomes.

Prescribed natural fire decisions must be good decisions. The uncertainty associated with prescribed natural fire decisions makes it essential that the decision maker clearly understand the tradeoffs of the decision.

Risk Assessment - Plans currently in existence do not do an adequate job requiring risk assessment and display because very seldom, if ever, do they display the consequences of failure to the decision maker. Therefore, the decision maker may not be fully informed when the decision is made.

Risk assessment is built into the phases of prescribed natural fire management. The planning process, which determines program feasibility, starts narrowing the risks for the program. In areas where the risks are completely unacceptable, the program will not be recommended and thus, risk eliminated.

In the initial "go/no go" decision on prescribed natural fire risk is analyzed based upon historical expectations. This initial decision is validated with a site specific analysis in the preparation of the Prescribed Natural Fire Burn Plan.

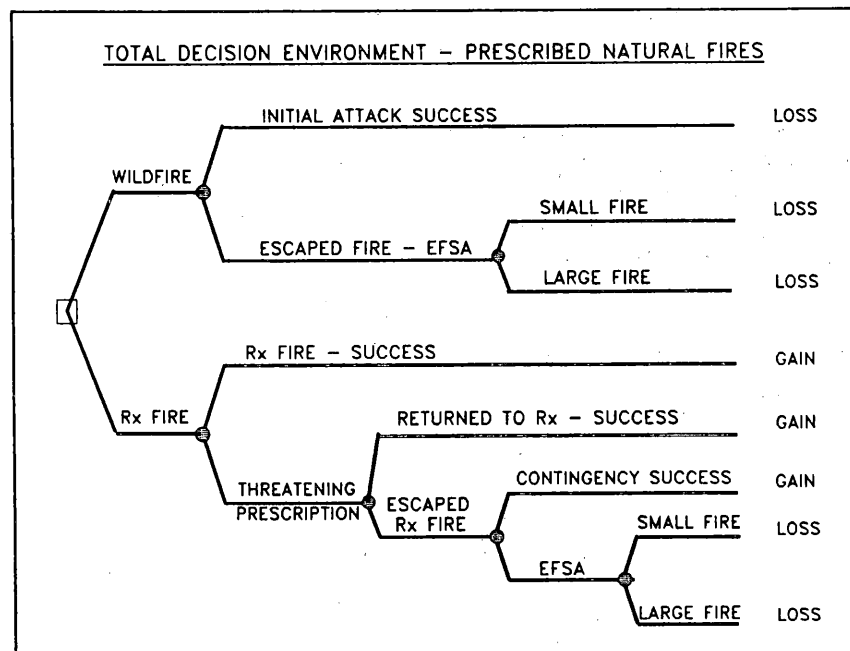
Many existing plans use recurrent validation in place of decision analysis at the initial decision point. Current plans revisit the prescribed natural fire decision daily. The belief is that if it is okay today, and predicted to be okay tomorrow, we can let it go until tomorrow and see what happens. We will check each day to see if it is still okay to continue.

Using this approach may set one up for failure. It inherently assumes that if, at any time, it is not okay, we can do something about it. As we observed in 1988, that wasn't the case. When it came time to change our minds and suppress the fires they were much too large to succumb to our actions.

The process of recurrent validation in place of decision analysis is inappropriate for prescribed natural fire decisions. The very best job of decision analysis must be obtained in the initial decision.

Risk assessment (decision analysis) is not difficult. Figure 1 portrays a typical decision tree which illustrates the potential outcomes associated with the prescribed natural fire decision. Successful risk assessment estimates the probabilities and consequences (expected values of gain and loss) for each potential outcome. Quantifying and displaying these risks to the decision maker is essential to good decision making.

FIGURE 1



Incorporating and displaying an appropriate risk assessment model into prescribed natural fire planning and decision making is recommended. By doing so, risk assessment shortcomings in existing plans will be remedied, and future plans will lead to better decisions.

A complete discussion of decision analysis, risk assessment, and wilderness fire management's role in each, is given in Appendix B.

Decision Processes - Existing plans rely heavily upon flow charts as the decision process. The flow charts lay out the decision criteria in a linear pattern. One criterion is judged and if the conditions are acceptable the next criterion is evaluated, and so forth down the list of criteria.

This process seems to work well. The major shortcoming is that it hasn't allowed risk assessment on each of the decision criterion, or the assessment has not been documented. To improve the process, each criterion should be judged using the risk assessment model illustrated in Figure 1, or another appropriate model incorporating these concepts. In doing so you would have an assessment of the probability of having a problem, given the criterion at hand, versus the probability of not having a problem. As discussed above, the decision maker will know the probability of having an unacceptable fire behavior problem. Other criteria can be assessed in the same manner, for example, smoke intrusions, risk to life and property, and others.

Decision Criteria - Decision criteria in existing plans are varied and extensive. Fire behavior estimation, threats to life and property, smoke dispersion, resource availability (management and emergency), and recurrent validation (monitoring and evaluation of the on-going project) were common to most plans. In addition, most plans attempted to consider drought indicators in their decision flow charts, usually in the form of the Energy Release Component (ERC). Criteria discussed at length within the Task Force were those affecting fire behavior characteristics, including drought conditions, and resource availability.

Plans reviewed included some fire behavior elements which led to a "go/no go" decision. This is curious, since wilderness has no resource value threatened by fire behavior characteristics, and thus fire behavior characteristics may not be important because we are not estimating resource impacts. The traditional prescription elements such as flame length, fireline intensity, and rate of spread may be meaningless if the only consideration is wilderness management objectives. There may be other resource values, such as threatened and endangered species, private land inclusions, or cultural improvements, within wilderness that require consideration of fire behavior characteristics however.

The fire behavior question with respect to wilderness management objectives is really one of fire extent. If the fire will threaten a wilderness boundary, then a wildfire decision might result. A prescribed natural fire that exhibits a four foot flame length has no bearing on the wilderness management objective. The flame length could be one hundred feet, or one foot, it really doesn't matter, as long as the fire is playing its natural role and is expected to remain within the scope of the Prescribed Natural Fire Burn Plan. Therefore, threat of the fire leaving the wilderness, or spreading beyond some desired location, is an important decision criterion in many plans.

Resource availability as a criterion raises interesting questions. Resource availability may be used in place of many criteria currently found in plans. Resource availability should include the resources necessary to manage the project, resources necessary to prevent an escape (holding actions), resources necessary to take emergency action (contingency actions), and funding (simply another resource) necessary for a successful project. In one form or another all these criteria are resource availability criteria.

Resource availability is the responsibility of the decision maker. In any project it is the decision maker's responsibility to assure that resources necessary to satisfactorily complete the project are available and committed to the project. Thus, the decision maker has a positive responsibility to either commit, or negotiate

with someone else, the resources necessary. It appears that in some cases, the responsibility for assuring resource availability is not clear.

This is not to say it is the responsibility of the decision maker to provide all the necessary resources. It is perfectly appropriate to negotiate with neighboring forests, or the next organizational level, for resource availability and commitment.

Commensurate with resource availability is resource commitment. A guarantee of resources available to prescribed natural fire sometimes must be made for extended durations. The time that these resources are needed also needs to be guaranteed. This is not to say that the resources must be assigned to the prescribed natural fire, but simply, that there is assurance that when needed, the resources will be available in a timely manner and will be committed to the project for the time period needed. This commitment might have to extend over a long period depending on the duration of the prescribed natural fire operation.

A typical process to use when resource availability decisions and commitments are being negotiated is illustrated in Figure 2. The flow chart shows typical negotiation levels and guarantees necessary. In addition, a detailed discussion of other decision criteria and the ability to estimate the uncertainty of each, is given in Appendix C.

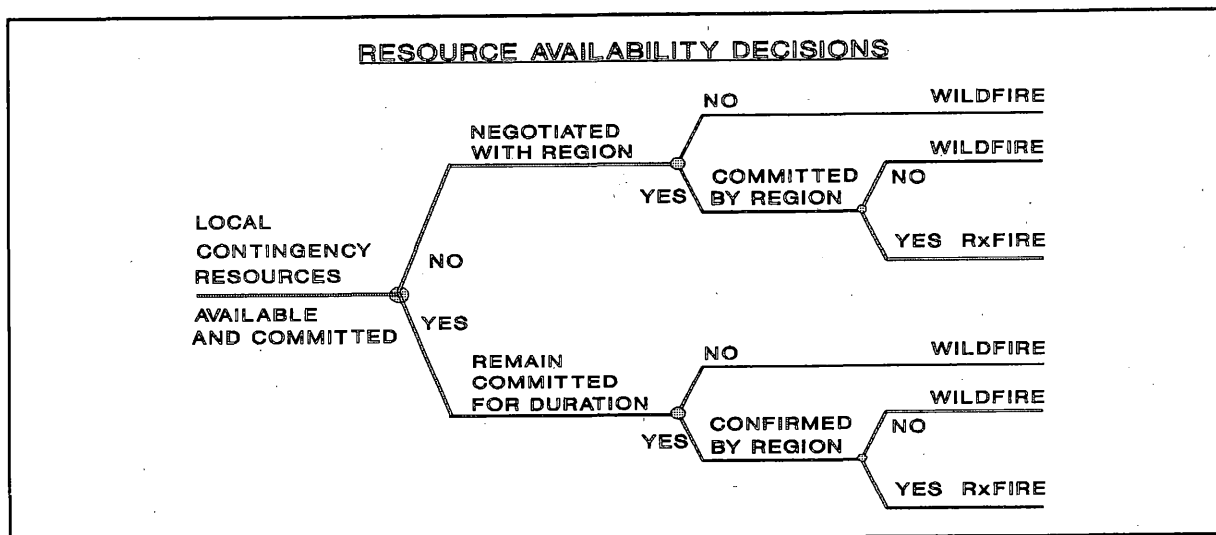


Figure 2

MANAGEMENT PHASE

The "management phase" of a prescribed natural fire is meant here to be those actions taken after a decision has been made to declare it a prescribed natural fire.

Prescribed natural fire is not common to all Regions and there has never been a Service-wide procedure for managing such an event. Each Region, and sometimes each Forest, has developed its own approach for

oversight and continuing management of a prescribed natural fire. Some efforts have been fairly complete and others have been less than that. Because of this variability in management procedures across Forest and Regional boundaries, it is difficult to get consistent agency and public understanding of the program and its management implications, especially in an eventful year like 1988. A standard methodology is needed to manage prescribed natural fire to enable the Forest Service to apply a consistent approach.

Once a naturally ignited fire is declared a prescribed natural fire it must receive a great deal of managerial attention to achieve a successful conclusion. Each fire should have an assigned project manager (Prescribed Fire Manager), responsible to the appropriate line officer. The manager's responsibilities should include, but are not limited to, preparation of a Prescribed Natural Fire Burn Plan; coordination between appropriate line officers when the fire involves multiple agency or administrative boundaries; and establishing requirements for monitoring in order to manage the fire as well as evaluate program effectiveness.

A Prescribed Natural Fire Burn Plan must be prepared and approved for each prescribed natural fire and must be completed in a timely manner in order to be an effective management tool. Normally this should occur no later than 24 - 72 hours after discovery and the initial decision has been made to designate the fire as a prescribed natural fire. This time frame allows the line officer sufficient time to adequately evaluate the circumstances of each ignition and should either reaffirm the initial decision to declare the fire a prescribed natural fire, or provide the basis to declare it out of prescription and take the appropriate suppression response. The plan documents the criteria that were considered in the initial decision and assesses long term implications of the fire. It should identify the criteria that will be evaluated on a daily basis by the line officer in order to validate that the fire is expected to remain within prescription. It should also specify the type of monitoring needed.

As a minimum, the Plan should contain basic geographic, vegetative, and weather data at the ignition point; established prescription parameters and documentation of actual conditions at ignition; fire projections using both an "expected" and "most severe" weather scenario displayed for the line officer; determination of the maximum allowable perimeter; estimates of resource needs; cost estimates; risk assessment; holding actions; contingency actions; process for information sharing; provisions for daily revalidation, monitoring, and evaluation.

Holding actions are critical to the successful management of the fire. Based on land and fire management objectives and the fire management organization's limitations, a maximum allowable perimeter for each ignition should be determined. This outer limit of acceptability should be determined as part of the Prescribed Natural Fire Burn Plan and represents defensible boundaries on the ground where suppression actions can be taken if it becomes necessary. Although it may happen on rare occasions, it is expected that this maximum allowable perimeter will change infrequently unless conditions significantly change from those present at the time of the initial assessment and development of the Prescribed Natural Fire Burn Plan.

Using site specific knowledge of fuels and topography, the Prescribed Fire Manager should develop opportunities to influence the fire's growth and spread so that it does not breach this maximum allowable perimeter. Planned actions must be tactically sound with sufficient emphasis on safety, resource availability and cost effectiveness. The needed organization, equipment and funding to implement the holding actions should be estimated at the time this portion of the Plan is prepared. Detail should be commensurate with the fire's current and expected level of activity and the probability of holding actions becoming necessary. This Plan must be reviewed and updated as necessary to remain current with any change in expected fire activity.

The decision to continue to manage a prescribed natural fire as such must be revalidated daily to ensure that the fire remains within prescription. This revalidation needs to occur to keep the line officers' actions in compliance with the fire policy model. Criteria in the initial decision should be evaluated during this revalidation. During this revalidation, criteria dealing with potential fire behavior (ERC, etc.) that was used in making the initial decision must be handled in a special way. It is recognized that in some cases the weather conditions will have exceeded this constraint at some point during the duration of the incident, and a criteria

that was used for a "go/no go" decision initially may not receive the same level of emphasis during the management phase. Each revalidation must be documented to show when it was accomplished by the appropriate line officer. The level of detail and effort involved in daily revalidation should be commensurate with current and expected fire activity, and the expectation that the fire will remain within the scope of the Prescribed Natural Fire Burn Plan.

The contingency section is required in order to specify the probable actions necessary in the event the fire is declared a wildfire. This could emanate from the fire exceeding the maximum allowable perimeter, or from another criteria being compromised. It is closely related to the holding plan but its "triggering" event establishes the point at which the fire can no longer be held within prescription and must be declared a wildfire. The contingency section should develop preliminary groundwork for determination of the appropriate suppression response or completion of an Escaped Fire Situation Analysis (EFSA). It should also establish an estimate of suppression resources needed to implement the probable strategy.

Post fire review of the fire perimeter projections and fire effects are needed to properly evaluate the program. This should be accomplished by the Prescribed Fire Manager and should include information such as:

- Documentation of all management decisions pertinent to the prescribed natural fire.
- A copy of the Prescribed Natural Fire Burn Plan.
- A project summary that analyzes the estimates (costs, size, fire behavior, etc.) in the Prescribed Natural Fire Burn Plan and compares these with the actual results obtained.

RECOMMENDATIONS

The Task Force recommends that:

1. Research and development activities for prescribed natural fire management be given high priority. Specific areas of need are:
 - a. Medium and long range weather forecasting (30-90 days such as the Canadian System and the Pacific Southwest Station efforts).
 - b. Mitigation of instrumentation (RAWS, etc.) on wilderness resource values.
 - c. Historical fire profiles for wildernesses.
 - d. Historical weather indicators related to fire history in wilderness.
 - e. Large fire growth modeling, including long distance spotting.
 - f. Research organization facilitation of technology transfer of wilderness management related knowledge.
 - g. Development of expert systems that aid and address the complex risk analysis situation.
 - h. Development of a severity index of vegetative/fuel conditions that displays critical thresholds for ecosystems where fire's natural role has been one of stand replacement fires.

2. Forest Service Manual 5140 be revised to address the unique differences of a prescribed natural fire program and specify the requirements of the plan authorizing a prescribed natural fire program and the requirements of the Prescribed Natural Fire Burn Plan for managing a specific fire.

3. Forest Service Manual 5140 revision addressed in Recommendation 2 include the following requirements:

A. The following elements are required to be addressed through the planning process before implementation of a prescribed natural fire program:

i. General description of the area

- History (including fire history)
- Objectives
- Acceptable outcomes

ii. Required skills, qualifications and organization necessary to implement and manage a prescribed natural fire program

iii. Funding requirements

iv. Inter/intra-agency coordination

v. Program Inform and Involve Actions (internally and externally)

vi. Potential impacts of plan implementation

- Environmental
- On/off site
- Socio-Economic
- Political

vii. Analysis and decision process that provides for:

-Identification of local approval authority

-Identification of evaluation criteria for the initial decision

-Risk assessment that considers the following criteria as a minimum:

- threat to life or property
- adequate availability of funds
- smoke management concerns
- local/regional/national fire situation based on availability of resources
- potential impacts on visitors, users, cooperators, communities, etc.
- fire proximity to plan boundary
- assessment of the amount of prescribed natural fire that is acceptable and manageable
- consideration of existing and predicted weather and fuel conditions
- drought evaluation impact and/or effect
- preliminary fire growth determination

-Provision for daily revalidation

-Timely decision by line officer

viii. Process for development of a Prescribed Natural Fire Burn Plan

ix. Process for monitoring and evaluation

B. The Prescribed Natural Fire Burn Plan must contain the following as a minimum:

i. General information, map, location, fuel type, etc.

ii. Fire projections using both "expected" and "most severe" weather scenario

iii. Identification of maximum allowable perimeter

iv. Estimates of resource needs to manage the fire

v. Cost estimates to manage the fire

vi. Risk assessment that portrays the estimation of the probabilities and consequences of the decision using the following criteria as a minimum:

-threat to life and property

-adequate funds available

-smoke management concerns

-resource availability for current and anticipated needs

-impacts on visitors, users, cooperators, local communities, etc.

-fire predicted to remain within the maximum allowable perimeter

-consideration of impact of other fire activity, both prescribed fire and wildfire, locally, regionally and nationally

-predicted weather acceptable

-drought trend acceptable based on an appropriate Drought Index

vii. Monitoring actions

viii. Holding actions

ix. Contingency actions

x. Provisions to keep the public, cooperators, users, and internal personnel informed

xi. Provisions for daily revalidation

xii. Decision criteria for daily revalidation

xiii. Identification of evaluation needs

4. Forest Service Manual 5140 be revised to require joint/coordinated plans where prescribed natural fire programs involve multiple planning unit, administrative unit, or other agency boundaries. Existing plans may use addenda or agreements where appropriate.

5. Forest Service Manual 5140 be revised to include necessary knowledge and skills standards related to prescribed natural fire and wilderness fire management. Elements to be included are wilderness values, wilderness management objectives, risk assessment, and management of long term fire situation. These additional elements will be at the expert level.
6. "Contingency Planning" (FSM 5121.2) related to a prescribed natural fire program be strengthened by:
 - a. Regions review Forest Service Manual 5121.2 (contingency plans) and 5140.41(6) and ensure they are in compliance.
 - b. Washington Office review compliance with Block 3 of Interagency Situation Report.
 - c. Washington Office recommend to National Wildfire Coordinating Group the requirement for all agencies to comply with Block 3 and 4 of the Interagency Situation Report.
7. Prescribed fire elements of the Fire Management Action Plan be strengthened in Regional Supplements to Forest Service Manual 5190 to give an adequate description of the prescribed natural fire program and the level of documentation required.
8. Regional Foresters identify knowledge and skills necessary to implement and manage a prescribed natural fire program, and inventory current capability to meet those needs. Based on inventory, Washington Office Recreation, and Fire and Aviation Management jointly develop a standardized training program to meet identified needs and maintain these standards for the future.
9. Regional Foresters aggressively assess the role of a management ignited prescribed fire program, as allowed by FSM 2324.2, within or adjacent to wilderness boundaries or private inholdings, and implement such a program where feasible and appropriate.
10. Recreation and Fire Management at the Regional Office level develop a program to insure that cross training in both wilderness and fire management awareness between both functional activities is conducted.
11. A National level effort, lead by wilderness management and involving fire planners and land management planners, address and clarify the objectives and planning process for prescribed natural fire within wilderness. It should deal with processes and expectations for new plans and amending or revising existing plans, and include National Environmental Policy Act (NEPA) requirements.
12. Training courses which address prescribed natural fire decisions should include the following instructional objectives:
 - a. The trainee will be able to describe decisions in terms of courses of action and probabilities of outcomes.
 - b. The trainee will be able to display the potential loss and potential gain of outcomes (risks associated with the decision).
 - c. The trainee will understand that quality decisions display costs and consequences of the decision.
13. Funding for prescribed natural fire programs be strengthened by:
 - a. The appropriate organizational level (RD/SO/RO) provide for appropriate methods of funding prescribed natural fire programs.

- b. Washington Office document the concept of funding prescribed natural fire programs by both primary and secondary benefiting functions, and provide this information to the field.
- 14. Washington Office Recreation, and Fire and Aviation Management prepare policy direction on: 1). the appropriateness of installation and use of weather instrumentation (temporary and/or permanent) necessary to provide weather data requirements for implementation and management of wilderness prescribed natural fire, and 2). acceptable level of fire management activity/impact associated with prescribed natural fire in wilderness (e.g., holding actions, limbing, line construction, black lining, backfiring, etc.), and the use of motorized equipment in managing prescribed natural fire.
- 15. Washington Office Recreation, and Fire and Aviation Management develop a national educational video on the Forest Service prescribed natural fire program.
- 16. Washington Office Recreation, and Fire and Aviation Management charter a follow-up Task Force during the first quarter of Fiscal Year 1992 to review the status and effectiveness of the revisions in policy and direction resulting from recommendations of the Secretarial level Fire Management Policy Review Team and the Prescribed Fire Management Criteria Task Force.

APPENDICES

APPENDIX A

TASK FORCE
ON
PRESCRIBED FIRE MANAGEMENT CRITERIA

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APPENDIX B

PRESCRIBED NATURAL FIRE DECISIONS: A RISK ASSESSMENT MODEL

INTRODUCTION

Decisions are the main topic of concern in the management of unplanned ignitions. Good decisions go a long way toward eliminating management problems.

In this appendix we will explore the major components of "good" decisions and propose they be used as judgement criteria on the performance of decision makers and staff officers. In addition, we will differentiate outcomes from the decisions themselves and propose that performance be based upon the quality of the decision and not upon the outcome.

Any discussion of decisions will naturally include a look at decision analysis. An existing model of risk taking will serve as the basis for looking into the prescribed natural fire decision. This model, called the Basic Risk Paradigm, is a useful tool in structuring decisions so one can illustrate outcomes.

Good decisions should include risk assessment. A model for assessing risk is presented which may be used for any decision objective.

Uncertainty of outcomes is a major influence on decision success. There are three areas which influence uncertainty, lack of control, lack of information, and lack of time. If we can better understand these influences we can improve our chances of a successful outcome.

The discussion concludes with a look at the important decision criteria which should be considered in any decision which allows and unplanned ignition to become a prescribed fire. The important criteria are assessed for our current ability to eliminate, or control, the uncertainty of the criteria, and, our ability to quantify risk.

DECISIONS

Quality implies subjectivity. When we judge something for quality we invariably bring our own bias into the rating. With that in mind, the discussion that follows attempts to present the aspects of quality in any decision.

Decisions result in outcomes. Some decisions are good and some decisions are bad. Likewise, some outcomes are desirable and some are undesirable. The trick to determining decision quality is to differentiate the outcome from the decision itself.

Any manager is striving to make good decisions in an attempt to maximize the number of good outcomes. However, people usually judge the quality of the decision not based upon the decision process itself, but rather the outcome. If a person decides to buy a particular model of car, after careful analysis of models and personal objectives, and the car turns out to be a lemon, has the person made a bad decision? Our postulate is that he has not. The outcome is undesirable, but the decision portrays all the necessary aspects of a good decision.

A decision can have either a desirable outcome or an undesirable outcome. There can be good decisions and bad decisions. Thus, there are four possible combinations. You can have a good decision with a desirable outcome, a bad decision with a desirable outcome, a good decision with a undesirable outcome, and bad decision with a undesirable outcome. Figure 1 illustrates the relationships possible.

Using our car buying example, we conducted the appropriate analysis of the alternatives and arrived at a decision on model of car. We implemented the action and the outcome was undesirable, a lemon. We would conclude, strictly based upon outcome, that we had made a bad decision. It is difficult to see how we might improve the quality of the decision. More analysis probably wouldn't lead to a decision to purchase a different model. Can we say the decision was bad, or, just the outcome? This paper would judge the decision to be good but the outcome to be unlucky. We knew there was a risk of getting a lemon regardless of the model settled upon. There always is that risk.

DECISIONS VS. OUTCOMES	
	OUTCOME
	DESIRABLE UNDESIRABLE
GOOD	Where you want to be
DECISION	Unlucky
BAD	Lucky
	Deserving

Figure 1

What would have happened had the car not been a lemon? Would the quality of the decision have changed simply because the particular car we received wasn't a lemon? No, the decision would still have been made given the same information. Nothing has changed except the outcome. In this case, this is exactly the situation we are trying to encounter most frequently, good decisions with desirable outcomes.

Of course that's what we try to do in any decision, maximize the probability of being in good decision-desirable outcome situation. The probability of being in any other box is an expression of the risk associated with the decision at hand. Said differently, we try to minimize the probability of any other decision-outcome combination. Implied in this goal is the understanding and analysis of risk for all alternative courses of action.

Let's look at the bad decision. Suppose we did no analysis what so ever. We simply chose a car model at random. We may very well have ended up with the same model and individual car that gave us the good decision-desirable outcome combination. But we would have arrived there purely by chance. We would have been lucky because the decision process we used didn't improve our chances of ending up with this outcome. On the other hand had we chosen a model that was undesirable, we would have gotten exactly what we deserved. (Notice we said model and not car. Each individual car might be a lemon, as opposed to the entire model line. The model line might not meet our particular needs, which is what we are analyzing in our decision process).

Decision quality is a function of the decision process and not the outcome. When we judge a decision we must be careful not to judge it based upon the outcome.

To bring the illustration closer to the point you might want to consider some of the unplanned ignitions that were allowed to burn as prescribed fires in the 1988 fire season. There is little question whether or not the outcomes of at least three of these decisions were undesirable. Whether or not the decision to allow the unplanned ignition to be a prescribed fire was bad is another matter. We would have to review the decisions to arrive at that judgement. The management review process on an individual fire is designed to make those determinations.

Good Decisions

Now that we have the foundation of the decision quality discussion in place we can identify the essential components of a "good" decision.

The decision process is important in the judgement of decision quality. The analysis aspects of making decisions are the most important determinants of quality. It is through analysis that the chances of a favorable outcome are displayed, and thus decision quality improved. If the chances of gain cannot be improved, at least the risk is identified so an informed decision can be made. Decisions then, are

good if thorough analysis has identified tradeoffs and risks associated with all courses of action as measured against the decision maker's objectives.

In our car model example, if you knew that there was 75% chance that a particular model wouldn't meet your personal objectives, would you buy it? No, but only because you had analyzed the happiness associated with the alternative.

As mentioned above, our measure of success is in maximizing our chances of desirable outcomes by understanding all the risks involved in the decision at hand. This reduces our chances of making bad decisions and ending up with undesirable outcomes.

ELEMENTS OF A GOOD DECISION

- I. Display clearly the objectives of the decision maker**
- II. Display risks and tradeoffs of all alternative courses of action for the decision maker**
 - A. Portray the chances of gain and loss associated with uncertain outcomes**
 - B. Portray the chances of gain and loss associated with certain outcomes**

A word needs to be said here about staff work and its role in decision making. The line officer (decision maker) measures success by maximizing the number of times the decision leads to a good outcome. The only way that can be accomplished is if the decisions are analyzed to the full extent of our capability.

The key to a good decision is good staff work. Analysis work which addresses the elements of a good decision is high quality, completed staff work. The analysis must portray all risks associated with the decision. To do otherwise masks the true consequences and represents incomplete work. In this context, both staff and line share the same definition of a good decision and quality staff work.

Decision Structure

There are five steps to deciding upon a course of action, define the problem, develop a model to represent the choices and outcomes, prepare the data for the model, model the solution, and present the results to the decision maker. These steps lead us to quantitative analysis of decisions. By completing each step with a high degree of professionalism, better decisions will result.

Our ability to model the problem at hand is directly related to the "goodness" of our decisions. If we can't model the problem adequately, the chance of making a bad decision increases dramatically because we can't portray the risk.

Any model has two kinds of inputs, those that can be fixed by us and those that are variable. In some instances we can determine an input to the model. A good example is our ability to build fireline and control the spread of a wildfire. In other cases we cannot determine an input. An example is wind speed. Both of these items, line construction and wind speed, affect how well we are able to model fire spread.

If we are certain that all of the inputs won't change, such as when we have control over them, then we can determine what will happen. the choice then is one of certain outcomes. We simply choose the one we like best.

As you would expect, the more inputs (variables) to the solution of the problem (model), the more uncertainty and lack of control there is in the decision.

Fire predictions are subject to variability. There is very little that is deterministic about fire behavior or seasonal severity predictions. We simply don't have the knowledge to be able to eliminate a great deal of the uncertainty in this business. We can estimate some probabilities but risk is still present. So we find ourselves confronted with outcomes which are uncertain. How do we decide which course of action to take?

The Basic Risk Paradigm

Risk is defined as having a choice with at least one uncertain outcome which exposes the decision maker to a potential loss. Clearly, most fire decisions have a component of risk to them.

A risk model, known as the Basic Risk Paradigm (MacCrimmon and Wehrung), diagrams this concept (Figure 2). Starting from a decision point there are two possible courses, one of which yields a certain outcome. The other course of action yields an uncertain outcome of potential loss, or, potential gain, depending on some state of nature that affects the outcome. The uncertainty of the loss gives us the risk associated with the decision.

There are things that we can do in our decision analysis to estimate the probability of incurring the loss. We still are subjected to the risk, but now we have quantified the risk. This risk identification allows an informed decision, and thus a quality decision, to be made.

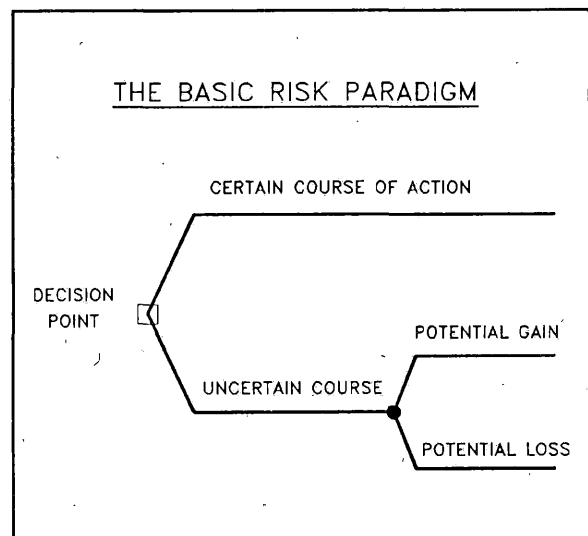


Figure 2

Many times decisions don't include analysis of the probabilities of the uncertain outcome. Without at least attempting to quantify this probability, no matter how crude, the decision maker is making an uninformed decision. It is best to estimate the probabilities of outcomes to the extent possible, even if subjective (Blattenberger, et al, 1984).

Referring to our criteria for a good decision it can be seen that the decision maker has made a "bad" decision if probabilities are not estimated. In fact, the decision maker may very well have accepted bad staff work, and as such, has been set up to fail.

The decision to use unplanned ignitions as prescribed fires fits the Basic Risk Paradigm framework nicely (Figure 3). The decision confronting us is a choice between declaring the ignition a wildfire, or, declaring it a prescribed fire. The wildfire may be considered as the certain outcome because we know what management actions are necessary. Under these actions we are not subjected to a potential loss from the decision and therefore we are not at risk. We are, of course, subjected to a loss from the fire itself, but not from the decision to call it a wildfire. We will never revisit the decision if it is called a wildfire.

The uncertain outcome is the prescribed fire branch. We can either have our prescribed fire stay in prescription or it can potentially become a wildfire. We will continually reassess the decision to see if conditions have created a wildfire. Uncertain states of nature will determine the outcome. The question is, "Can we do an analysis that will quantify the potential gains and losses associated with this decision given the uncertainty associated with the states of nature influencing the outcome?" We know that

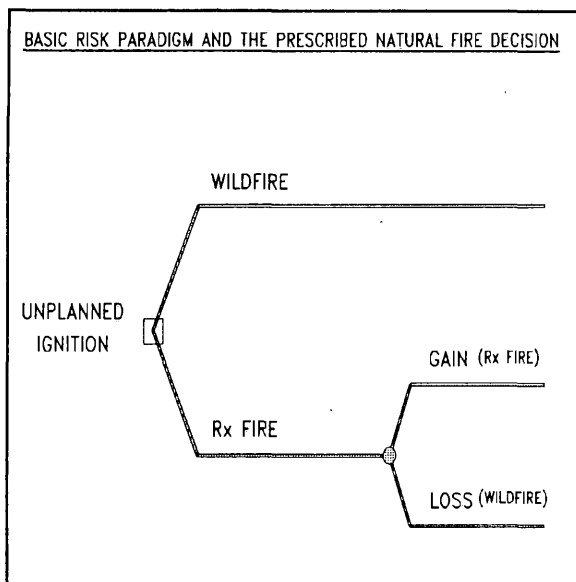


Figure 3

many inputs to this model vary in nature and are thus probabilistic.

Managerially speaking the wildfire decision is a certain outcome because it invokes set procedures and doesn't put the decision maker personally at risk. But in reality the wildfire outcome is subject to uncertainty with respect wildfire size and cost. The potential impacts may influence your initial decision.

Early in a fire season we may be able to assume that the wildfire outcome is operationally certain with respect to fire size and cost. Typically fire danger conditions are such that little resistance is given to our suppression efforts. Generally they are successful.

However, as the fire season progresses the outcome of a wildfire becomes less and less certain. The risk of making either a prescribed fire or a wildfire

decision increases as the uncertainty increases. The decision then becomes one of two uncertain courses of action (Figure 4) with respect to their potential impact. Obviously as the number of decision outcomes increase, or the uncertainty associated with each outcome (fire size and cost) increases, more thorough analysis is required to assure an informed decision.

Following the same logic, the potential prescribed fire outcomes are further complicated by the fact that the escaped prescribed fire outcome becomes uncertain itself. If things go awry, we may have success implementing our planned contingency actions, or, we may have an escaped wildfire just as we did under the wildfire decision.

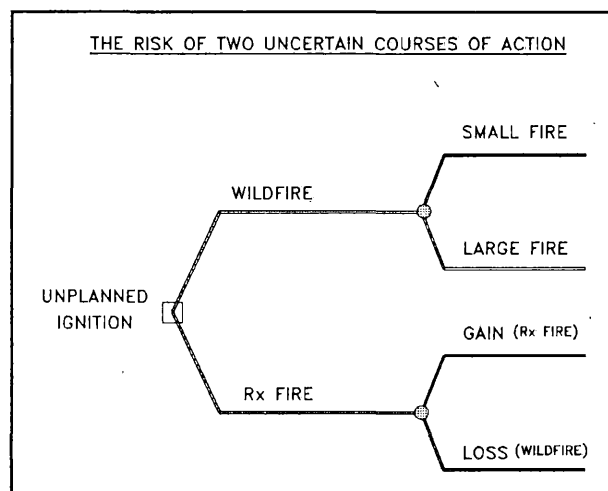


Figure 4

Figure 5 attempts to illustrate the entire decision environment for the prescribed natural fire decision. If a wildfire is declared, we can successfully attack it and end up with a small loss (cost plus loss). If initial attack is unsuccessful, we undertake an Escaped Fire Situation Analysis (EFSA) to determine fire suppression strategy. This results in either a small fire, or a large fire, with commensurate loss. We are categorizing wildfire outcomes here as small or large rather than complicate the issue with differing wildfire size classes.

If a prescribed natural fire is declared (Rx FIRE), it will either be successful (resulting in a gain), or, will threaten to be out of prescription. Once threatening, the prescribed natural fire can either be returned to prescription using project funds (FSM 5100), thus resulting in a gain, or, will become an escaped prescribed fire. Once the prescribed fire has escaped, contingency action is implemented. As in the case of the wildfire outcomes, the escaped prescribed natural fire results in either a small wildfire or a large one.

Given that there are seven potential outcomes, it is not surprising that some prescribed natural fire decisions are made without analyzing all outcomes in terms of the risk the decision presents.

And, of course, the decision is validated daily. Nothing remains constant in the decision scenario.

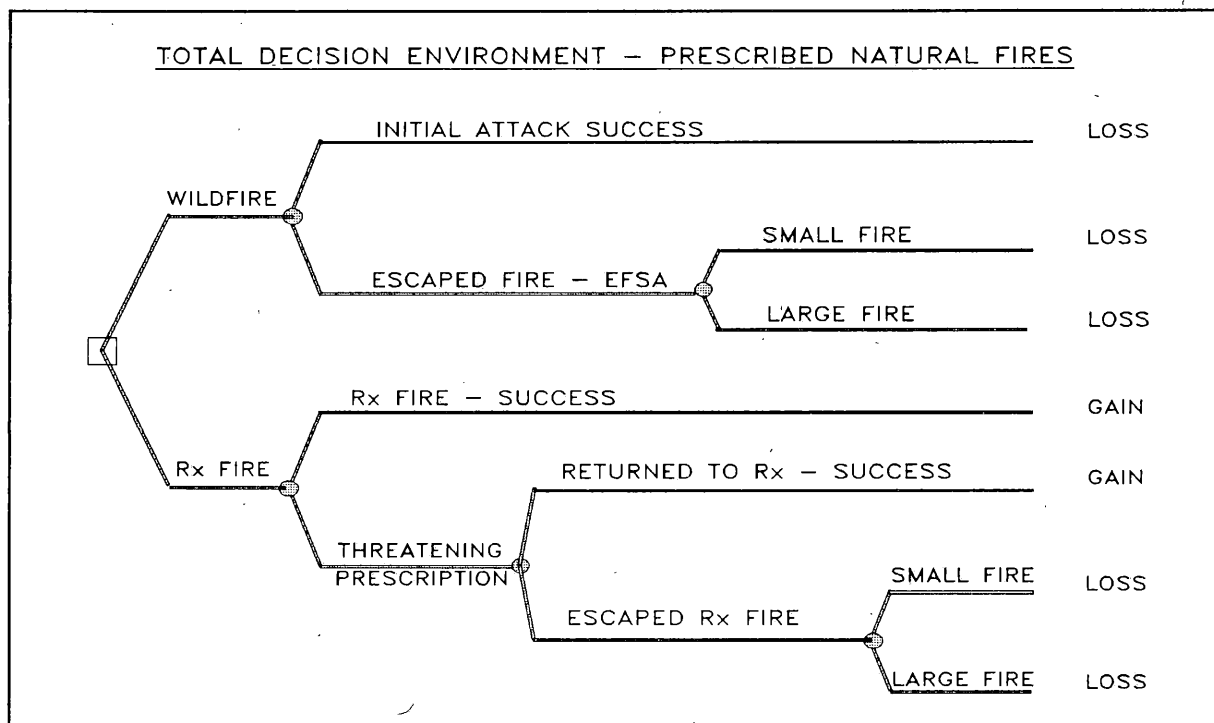


Figure 5

Applying our decision quality criteria to this sticky problem means we have to conduct quite a lot of analyses daily to be assured of quality decisions. Perhaps inclusion of the increased probability of a bad outcome can be factored into the original decision, thus eliminating the recurrent analyses?

Figure 6 estimates probabilities for the historical (1972-1988) Forest Service prescribed natural fire program. The numbers are estimates because records are not kept in the categories displayed. The estimates of the outcomes are in terms of numbers of fires and acres burned and include only those wilderness areas that are managed under a prescribed natural fire program. The division between large and small wildfires was set at 1,000 acres arbitrarily. The probabilities in each category are calculated below.

It is estimated that there is approximately a 96% probability that a wildfire will end with successful initial attack, a 3% chance of having a small fire, and a 1% chance of having a wildfire greater than 1,000 acres in wilderness areas that are managed under prescribed natural fire programs. There is 95.6% chance of having a successful prescribed natural fire. These successes average 403 acres each. There is a 1.8% chance of having a small wildfire averaging about 150 acres. Finally, there is a 2.6% chance of having a large wildfire result from an escaped prescribed natural fire. These large escapes average about 38,674 acres. Further, the majority of the escaped prescribed natural fire acreage has occurred since 1985, a fairly recent period.

In the 1988 season, if we had known these for certain when the prescribed natural fire decisions were made, we might have made different decisions. Of course we might not have, we may have decided to accept the risk. Remember also, that the probabilities of losses were much less prior to the 1988 season. The outcomes associated with wildfires led to a Forest Service suppression expenditure in excess of \$413 million.

This illustrates the point succinctly that we need to look into our decision process rather than judge the 1988 season based upon outcomes. Clearly, the results of 1988 are undesirable (fire size and cost), but were the decisions that got us to the outcomes also bad? Can we improve those decisions? What are the critical factors in making those decisions?

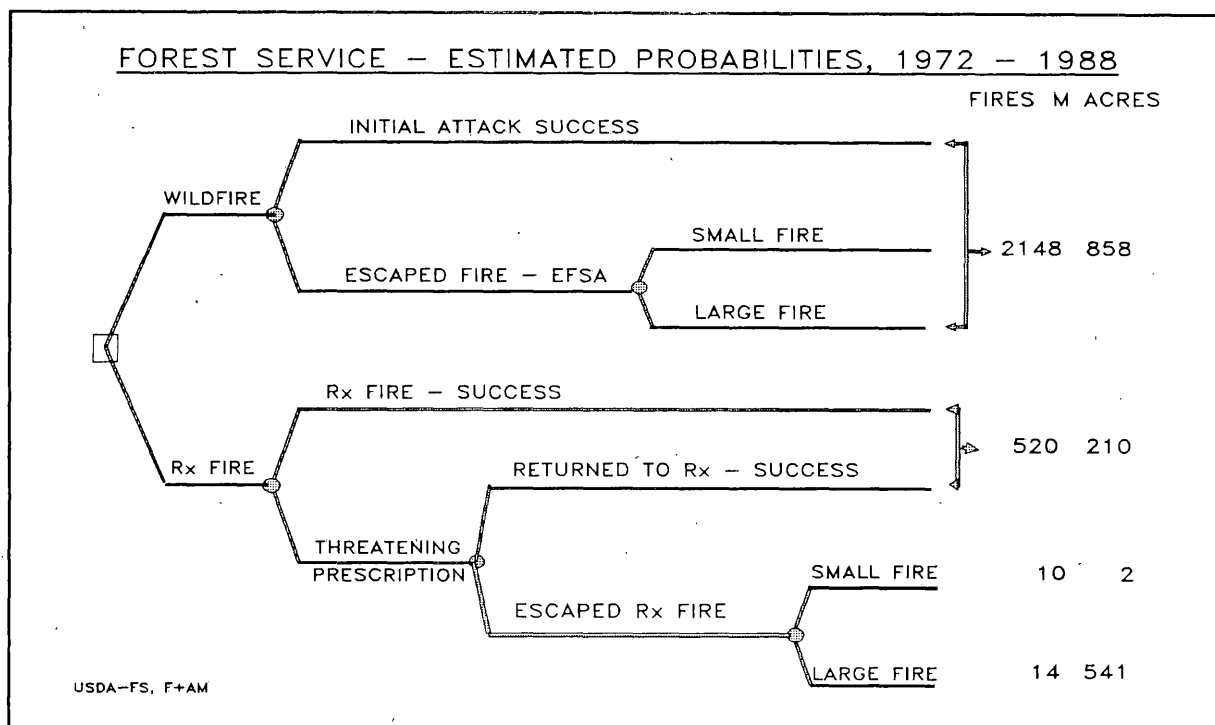


Figure 6

RISK ASSESSMENT

It is impossible to make informed decisions if the risks associated with the outcomes are not displayed for the decision maker. Earlier in this paper the definition of good decision was established as one which was made knowing the risks and consequences associated with the alternatives. Risk assessment is the key to good decisions. Quite simply, risk assessment is the estimation of the probabilities, and consequences, of the decision at hand. Figure 6 is an example of risk assessment for the prescribed natural fire program in the Forest Service. Any single prescribed natural fire decision should have a similar risk assessment made for it.

If we ask a decision maker to choose the prescribed natural fire course of action, isn't only fair the decision maker is aware that there is a 2.6% chance of having a 38,674 acre escaped prescribed fire? The tradeoff is a 95.6% chance of a successful 403 acre prescribed natural fire. This exemplifies risk assessment and display for the decision maker.

The probabilities illustrated in Figure 6 are for an entire program. Individual decisions will require estimates of the probabilities, gains, and losses (expected values) associated with them. The art of assessing risk has its basis in estimating (or calculating) probabilities, gains, and losses.

Much of the probability information may have to be estimated because it will vary dramatically for each fire decision to be made. The time of year will greatly influence the probability of an escaped prescribed natural fire. The location of the fire will definitely influence your probability of success. Given fires in the same location on two different months, the probability of success may be much different for each fire. Similarly, fires in two different locations on the same day might have dramatically different probabilities of escape.

The risk assessment example discussed considers only the outcomes associated with fire behavior and the objectives of minimizing losses and maximizing gains. Similar models could, and should, be developed for other sensitive objectives and decision criteria.

An example might be smoke management. Even though you don't expect your average condition to give you a smoke problem, there is some probability that you will have one. Knowing the probability of the problem, and the value associated with it (loss in this case), the decision maker can rationally decide if the chance of gain from the prescribed natural fire is worth taking the risk of having a smoke problem.

All decision criterion can be framed in this context. In so doing, complete risk assessment is accomplished. The go-no go decision criterion also fits this framework. The probability associated with the go-no go criterion is either 1 or 0. That is, it will or will not happen. The value will either occur or it won't. Consider smoke again, but this time as a go-no go decision criterion. If you can't tolerate a smoke problem (high value of loss), and there is some probability of having a smoke problem, the decision is made for you. You set the probability of a smoke problem to 1, certainty. Then, you cannot allow the fire to burn as a prescribed natural fire because you cannot tolerate the result. The decision maker avoids the risk.

Many decision criteria are similar, you cannot tolerate the loss regardless of probability. If there is any chance, then it is unacceptable. These criteria are, in the true sense of the word, go-no go. The decision maker must identify these and assess them first before continuing on to any risk assessment. There is no need to complete a risk assessment if the project won't continue.

In summary, risk assessment is simply attaching realistic probabilities and values on the outcomes illustrated in Figure 5. These will vary depending on the conditions at the time. Displaying the results for the decision maker will lead to informed decisions where tradeoffs are illustrated.

SOURCES OF RISK

We have shown that the unplanned ignition outcome is subject to a great deal of risk and uncertainty. Where might that uncertainty come from and is there anything we can do about it?

Risk is determined by three things, the lack of control over the situation, the lack of information about it, and the lack of time to deal with the situation (Table I).

The lack of our ability to control the events surrounding our decision comes from several places. In the fire business it usually comes from weather. There isn't a lot we can do about the weather which influences our fire. There other areas where we lack control, such as the number of resources available to us to help control the situation. People and money are the two resources whose availability is not always certain. Lastly, one has to consider the human aspects of control. We sometimes just don't know what someone will do. There is uncertainty in people, it is their nature. In fact, decision makers may not even understand the basic principles of risk and probability and may not use them to influence their decisions (March and Shapira, 1987).

On the other hand, we can control some things and fuel treatment is a good example. We might be able to reduce uncertainty of wildfire outcomes to some degree by treating fuels in advance of a wildfire.

Frequently, in fire decisions we lack sufficient information to make an informed decision. Our information can be unreliable or simply inadequate. Many times the situation is unfamiliar to the decision maker. A line officer confronted with an prescribed natural fire decision may be so unfamiliar with the circumstances and risk environment that a quality decision is impossible. Many line officers are inexperienced in this area.

Of course time is a necessary component to quality decisions. The lack of time is the main reason we try to plan our decision processes ahead of time. A crisis might easily be defined as a decision which has all uncertain outcomes subjecting us to risk, and, which has to be made immediately. Naturally

Table I.

DETERMINANTS OF RISK AND THE EFFECT ON POTENTIAL LOSS		
<u>DETERMINANTS</u>	<u>MAGNITUDE OF LOSS</u>	<u>CHANCES OF LOSS</u>
<u>Lack of Control</u>		
- Natural forces	Can't affect size of the loss if you can't control it.	Can't affect chances of loss without control.
- Human factors		
- Insufficient resources		
<u>Lack of Information</u>		
- Inadequate	Don't know size of of the potential loss without information.	Do not know chances of potential loss.
- Unreliable		
- Unfamiliar		
- Unpredictable		
<u>Lack of Time</u>		
- Short span	Insufficient time to understand the loss or try to reduce the loss.	Insufficient time to estimate chances of loss.
- Uncertain span		
Source: The Management of Uncertainty, Taking Risks, MacCrimmon and Wehrung		

we must hurry and make the decision before time makes it for us. The prescribed natural fire decision falls into this category of urgency. A timely decision is critical to a successful outcome, especially if the decision is to call the ignition a wildfire. Successful initial attack and time until attack are inversely related.

These three determinants of risk can combine with the magnitude of the potential loss and the chances of potential loss to create a decision environment which is difficult to cope with (Table I).

Risk assessment (decision analysis) requires consideration of all the variables listed above within the decision environment. Implementation design may well be influenced by the analysis. If uncertainties can be eliminated by mitigating measures discovered during the analysis, chances of a good outcomes are increased.

WILDERNESS PHILOSOPHY AND MANAGEMENT DECISIONS

Through review and discussion of prescribed natural fire plans and operations it became clear that the management interpretation of wilderness direction and philosophy greatly influenced what would or could be done. Thus, risk is generated by our lack of knowledge about wilderness management. An

example is the amount of mop-up that can be allowed; some say none, some say all.

Operational Considerations in Prescribed Fires

The wilderness management model (Figure 7) provides some philosophical insight (FSM 2320.6). The goal of wilderness management is to move the state of wilderness from its present degraded state of purity (due to human influence) to its attainable state of purity. Where choices are made between wilderness values and use, wilderness values prevail. Forest Service guidance on fire management activities (FSM 2324.23) seems to be strongly related to wildfire suppression activities. Clarification of acceptable prescribed fire activities, including guidance on fireline construction and use of mop-up, needs to be written. Human influence

associated with prescribed fire activities are not well specified and thus ambiguity in prescribed fire operations exists. If wilderness philosophy is founded in the purist concept, such that man cannot be allowed to impact the ecosystem in the slightest, the operational decisions become greatly limited. If, on the other hand, the philosophy allows man's uninhibited influence on the landscape, operational decisions will vary little from those undertaken in planned ignitions. This range of wilderness philosophy (and interpretation) may be causing us to accept a great deal of uncertainty because we lack control over the situation.

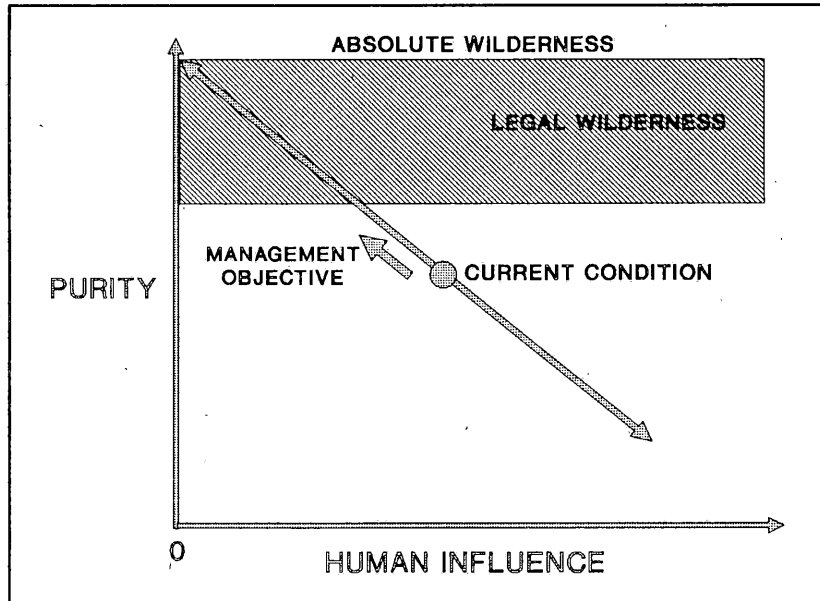


Figure 7

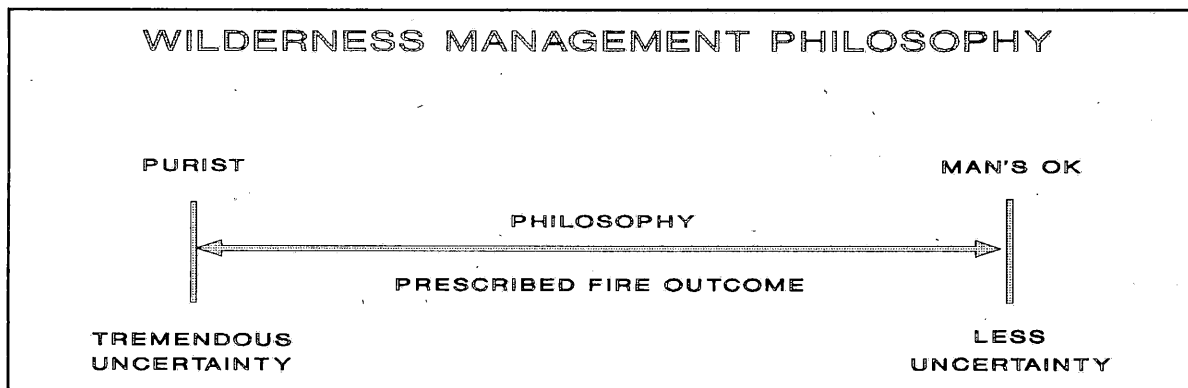


Figure 8

When making decisions under the purist interpretations man can do little to influence the eventual course of an unplanned ignition. Basically, the decision to allow the unplanned ignition to be a prescribed fire is man's only influence on the outcome. The outcome, under a purist philosophy, is left totally up to Mother Nature. Of course this leads to a tremendous amount of outcome uncertainty, and thus risk (Figure 8).

On the other end of the spectrum is decision making under a philosophy that man is allowed to do all

he can to control the outcome to reduce risk (commensurate with land management objectives of course). We are still at risk due to the lack of information and time, but we now have some ability to control the situation.

This philosophical uncertainty in the Forest Service must be eliminated before we can determine the soundness of prescribed natural fires in wilderness. An analogy currently exists in the wildfire suppression business where there are a variety of interpretations on wildfire suppression policy which have led to some undesirable outcomes.

With the elimination of the philosophical uncertainty comes the definition of what we can and cannot do operationally on prescribed natural fires. The choices range from nothing to full ability to maintain prescribed fire control.

Character of Fires

The establishment of an understood wilderness philosophy not only will determine operational considerations but it will also help to establish acceptable fire character.

In some cases that historically fire's role in the ecosystem has been one of replacing stands of trees. Our current prescribed natural fire program is designed to allow natural fires to play their role in ecosystems. Are stand replacement fire characteristics acceptable?

The Canyon Fire (Lolo NF) ended up at over 200,000 acres and exhibited some extreme fire behavior in places. This type of fire has visited this ecosystem before and thus can be considered to represent, at least in part, the natural role for fire in that ecosystem. Yet our management environment won't allow this fire to occur on a prescribed basis. Or at least some believe, operationally, that we can't allow this kind of fire character to occur.

Prescribed natural fire plans (or planned ignition prescribed fires in wilderness) usually don't allow a fire with stand replacement characteristics to occur. We simply believe that these kinds of fires are managerially unacceptable. Thus, we allow fires of much less threatening fire behavior to occur. It would seem that allowing a prescribed fire to occur that is not natural (lesser fire behavior) is in violation of the wilderness fire policy in itself. Some prescribed fires should be allowed which exhibit stand replacement fire characteristics but yet we don't allow them to occur. The conclusion might well be an "unnatural fuels buildup" due to our wilderness prescribed fire program! A Catch 22 if ever there was one.

The clear establishment and understanding of what is, and what is not, acceptable in our wilderness ecosystems is essential to successful wilderness management. The Forest Service is not ready to manage wilderness because we have not established management philosophy that is clearly understood and accepted by our land managers.

CONCLUSION

The risk assessment model presented can be used to analyze potential outcomes of prescribed natural fire decisions, regardless of the decision criterion being assessed. In doing so an informed decision will result from adequate risk assessment, and therefore, a defensible decision, regardless of outcome. Wherever possible, management should eliminate ambiguity and confusion in policy and philosophy so that maximum knowledge and control can be brought to bear over the naturally uncertain role of fire in wilderness ecosystems.

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APPENDIX C

DECISION CRITERIA APPROPRIATE FOR PRESCRIBED NATURAL FIRE DETERMINATION

INTRODUCTION

We have previously discussed the decision structure and environment for determining if an unplanned ignition is to be called a prescribed natural fire, or, if it is to be called a wildfire. Now that we have the generic decision structure in place we will discuss some of the criteria that are appropriate for this decision, and, our ability to quantify them.

Because our definition of a good decision requires that we quantify potential outcomes to the extent possible, it is important that we understand how well we are able to do that. Any lack of ability to quantify a particular criterion will increase the uncertainty associated with the criterion because we will lack knowledge of the outcome. This discussion uses the concepts for the determinants of risk presented earlier, lack of control, lack of knowledge, and lack of time to deal with the problem.

It is timely and appropriate to discuss decision criteria. The prescribed natural fire program began in the early 1970's in the Selway-Bitterroot Wilderness. The decision criteria in that first plan are essentially replicated in today's plans. Little change has occurred to those criteria. In addition, the inter-departmental Report on Fire Management Policy (Philpot, et al, 1988) stresses the importance of decision criteria and weaknesses found during the policy review.

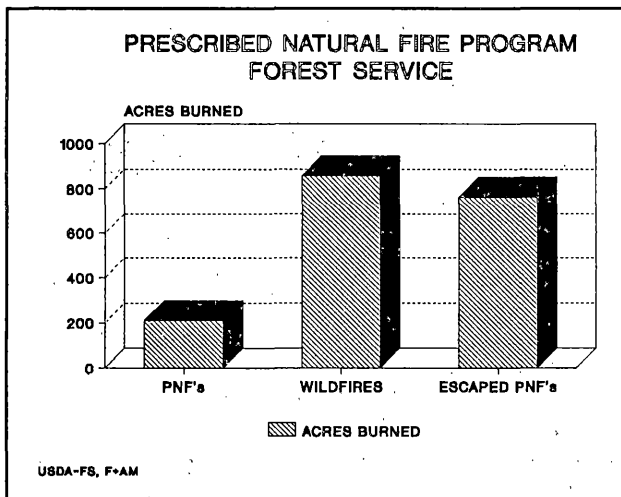


Figure 2

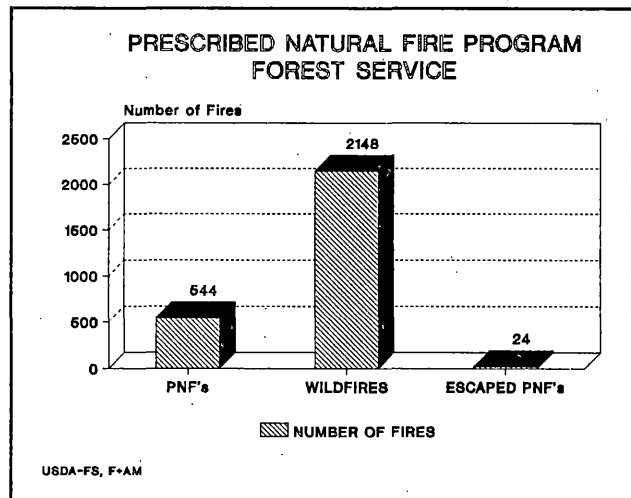


Figure 1

Figure 1 illustrates the number of ignitions under the prescribed natural fire program in the Forest Service since its inception in 1972. Data are given from three sources; wildfires, wildfires resulting from escaped prescribed natural fires, and prescribed natural fires by themselves. Figure 2 presents the same historical data for acres burned.

Comparatively speaking, the data indicate that we haven't managed a large percentage of unplanned ignitions as prescribed fires (Figure 1). Out of 2,692 ignitions, only 544 (20.2%) of them were declared prescribed natural fires.

Furthermore, we haven't had a significantly large amount of acres treated by prescribed natural

fire, or, a very large amount of acres burned by escaped prescribed natural fire until the 1988 fire season. In 1988 we burned 123,716 acres successfully using prescribed natural fire which represents 59% of the total for the program (209,731 acres). The next highest accomplishment was 20% in 1979. The average annual acreage burned in prescribed natural fires since 1972 has been 12,337 acres. In 1988 it was 123,716 acres, or, 10 times the average annual acres burned. Escaped prescribed natural fires during the 1988 season accounted for 53% of the total wildfire acres burned in wilderness since 1972. One fire season, 1988, out of the last seventeen, accounts for over 60% of the total wilderness fire management business (wildfire plus prescribed fire acres). We have generally assumed that our decision criteria are acceptable and appropriate. The criteria in the existing plans have had no severe test until the 1988 fire season.

DECISION CRITERIA

The plans reviewed had the following decision criteria in common:

1. Fire Behavior/Fire Perimeter Estimation
2. Threat to Life and Property
3. Smoke Dispersion and Effect.
4. Resource Availability for Emergency Suppression
5. Recurrent Validation Using Actual Fire Conditions.

Others included such things as drought indicators and predictions in the form of 1000 HR fuel moisture or ERC values, recreation monitoring involvement, Regional fire preparedness level, on site weather monitoring, and others.

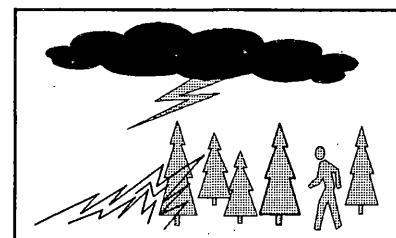
The discussion that follows deals with the criteria that are used within an prescribed natural fire project plan. This discussion assumes that the decision to have an prescribed natural fire program has already been made. Forest Service policy (FSM 2324.2) is very specific about the process, and, the necessary items which have to be covered in that process, to determine if a program is desirable.

Fire Behavior/Fire Perimeter Estimation

All plans require some estimation of fire behavior potential. This is usually required to be in the form of an estimate of fire perimeter location over time, but may come in the form of a given spread or fireline intensity.

Some plans require specific qualifications of personnel estimating fire behavior, others do not. Some plans stipulate time periods for perimeter estimation, for example, "end of the burning period", "1800 daily", or "next five days."

In any case, fire behavior estimation is the most critical input to the prescribed natural fire decision. Without some idea of current and future fire behavior and fire growth, an uninformed decision will surely result.



Our current ability to estimate fire behavior was developed in the late 1960's and published by Richard C. Rothermel in 1972 as the fire spread model. Interestingly enough, many believe our capability to estimate fire behavior has been greatly enhanced in recent years. The truth is that our current ability is no different than it was 12 years ago when we conducted our first Fire Behavior Analyst (S-590) training session using the fire spread model as the predicting method. The underlying fire behavior model has not changed since 1972. Computerized prediction, and models for spotting and fireline intensity estimation have been added, but the basic fire spread model remains unchanged. We have simply enhanced our ability to use the basic model developed in the late 1960's by employing new technology, not new science.

The inherent accuracy of the fire spread model is estimated between 50% and 200%. In other words the actual fire spread rate on a fire may be as little as 50%, or as much as 200%, of that predicted by the model. For example, if we have predicted a fire spread rate of 10 chains per hour using the fire spread model, the actual rate of spread of the fire may well be as little as 5 chains per hour, or, as much as 20 chains per hour, or, anywhere in between.

In addition to the inherent inaccuracy of the fire spread model the inputs; fuel, weather, and topography, also vary. Topography varies depending upon fire location, and, fuel moistures and fuel types vary throughout the fire area and over the time the fire burns. Fire spread estimation typically is accomplished by estimating the variation by selecting an average condition, or perhaps worst case condition. Thus, inaccuracies are also prevalent in the input estimation part of the modelling process.

None the less, the fire spread model and current fire behavior estimating techniques are far superior to any other form of fire behavior prediction. These tools have served us well when used by practitioners who understand the proper techniques of fire behavior estimation and have experienced actual fire behavior in the field.

The uncertainty associated with fire behavior estimates clearly comes from our lack of knowledge of inputs, and, fire spread processes (the model itself). There is much we don't know about the fire spread process itself. In fact, the Intermountain Forest Sciences Laboratory at Missoula has chartered a new work unit to develop a new fire spread model which will incorporate our current knowledge and improve our current model.

Lack of knowledge also is associated with the inputs to our existing model. We estimate weather and fuel inputs. The amount of time we have available to make the decision influences our ability to predict accurately. We must make a fairly quick decision in this instance and thus we do not have the luxury of spending a great deal of time gaining more knowledge about the weather or fuel conditions currently affecting the fire, or more importantly, those that will affect it in the future.

In addition, our ability to predict weather conditions in the future is greatly limited. Our best weather estimates are given within the next 5 days. Great uncertainty exists beyond that point. We have some weather products that forecast future trends, such as 10 day, and 30 day outlooks, in terms of temperature and moisture variations from normal. These outlooks do not predict actual values of temperature and precipitation, only variations from normal. In addition, these outlooks don't even mention some of the necessary inputs to fire behavior prediction, such as relative humidity and wind speed. As such, they are of limited use in the estimation of fire behavior because the fire spread model requires specific input values for fuel moistures and wind speeds. Thus, more uncertainty in fire behavior exists because of our limited ability to predict future weather conditions.

There are some research products in the laboratory today which will aid us in predicting fire behavior in the short term (up to 5 days out). The Pacific Southwest Fire Sciences Laboratory is developing predicting products for necessary fire behavior inputs within this time frame. Wind speed predictions

are the most critical element in predicting fire behavior. The products under development will help predict this input.

Probably the best estimate of potential fire behavior is generated using climatological probabilities of input values. In some cases, but certainly not all, weather records are available which can be used to estimate probabilities of inputs. Thus, we can generate fire perimeter and spread estimates, along with the probability of these occurring. These products are different than an actual forecast of where the fire will be but can give the decision maker a good indication of the average, and worst case, scenarios with respect to historical climatology.

In areas where climatological data are lacking, we simply have no good way of estimating potential fire behavior. The weather station network is of vital importance in establishing the climatological record. The validity of any climatological data is an important consideration. If sufficient data are not available, it is very difficult to estimate potential problems.

We must be careful to include all climatological records however. If we rely solely upon fire danger rating weather records our historical period may be too short to recognize the climatological probability of significant events, such as 50 year storms, or, a 1 in 100 chance of extremely high winds.

The use of climatology as the source of weather inputs for fire behavior prediction rids us of the need for weather forecasts in this decision process. We can use the climatologically generated fire behavior in the initial decision. We can then monitor the fire situation and use forecasted values in the recurrent validation of the decision.

We have traditionally approached the uncertainty of fire behavior by requiring recurrent validation of the decision. That is, we check each day to be sure we are still under acceptable fire behavior conditions. In this way, we only need to be accurate within the next 24 hours. The problem with relying on recurrent validation is that you automatically assume you can choose and implement an alternative course of action with certainty, which is rarely the case. As time progresses and fire grows, certain, desirable outcomes become scarce.

There is another problem with this approach, it takes time to complete. Generating probabilistic scenarios of fire behavior takes a long time. It takes time to obtain the necessary data and it takes time to run the model and prepare the outputs for interpretation and display. Clearly, we need to develop new techniques which allow for more timely information processing in this regard. Two possible areas need exploration simulation and gaming.

The appropriate way to include fire behavior in the initial decision is not through a requirement of recurrent validation, but rather through scenarios generated to represent probable fire perimeters in the future. In terms of risk assessment, this approach simply estimates the probability of having a problem in the future. Then an informed decision can be made based upon some idea of the potential fire size in the future. As mentioned, we can generate these perimeters from climatological probabilities of fire behavior model inputs.

This is not to say there is no place for recurrent validation, there certainly is, especially in monitoring. However, recurrent validation should never take the place of risk assessment.

Perhaps a better criterion is not fire perimeter, or, fire behavior, but rather some critical value of spread distance. In many cases the decision to allow a prescribed natural fire to occur is not a function of the fire perimeter location at some future time, but rather some estimate of whether the perimeter will be past a given location (such as a wilderness boundary). The important distinction here is that we are dealing with some critical spread distance (distance to the wilderness boundary) rather than an

estimate of where the perimeter might be on any given date. This simplifies the problem considerably.

It is usually much easier to determine whether or not a fire will spread past a given point than to determine exactly where the fire will be in the future. Any prescribed natural fire plan should include this consideration in risk assessment. An estimate of the probability that the fire will spread beyond some critical location, and thus cause an unacceptable loss, must be included in the initial decision.

Threat to Life and Property

This criterion is in effect a constraint. If there is any perceived threat to life or property the fire is immediately called a wildfire. It is the single most important over-riding factor in the decision to use prescribed natural fires.

Our current ability to estimate threat to life and property is limited by our ability to estimate fire location (as mentioned in Fire Behavior/Fire Perimeter Estimation above).

The discussion concerning critical values in the section above should be reviewed for this discussion. If the problem of threat can be stated in terms of threshold spread distances, or some other critical value, then the estimation process is much simpler. As in the case of threat to the wilderness boundary, threat to life or property must be carefully considered in the initial decision to use an ignition as a prescribed fire. It may be too late to change your mind later in the sequence of events. Fire behavior may cause a threat and there may little than can be done about it.

Resource Availability for Emergency Suppression

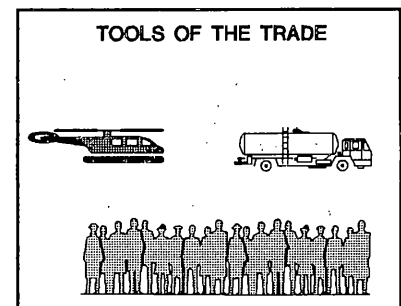
Almost all prescribed natural fire plans include a decision criterion related to the availability of resources for the suppression of the fire (wildfire) if necessary. The intent of this criterion is apparently to give some comfort to the decision maker about the capability to suppress the fire should it be called a wildfire later on.

The criterion occurs in recurrent validation phase of the prescribed fire. That is, the decision maker revisits this criterion daily. If resources are available to suppress the fire, then the fire is allowed to continue as a prescribed fire. The knowledge that resources are available to help should things go awry is comforting. If resources are not available then the fire is called a wildfire and suppression action is taken.

It is interesting to note that the course of action prescribed if firefighting resources are unavailable is to call the fire a wildfire and, presumably, order some of those unavailable resources to suppress the fire. The decision is a paradox, if no resources are available to suppress the fire then go ahead and suppress the fire.

In any project, especially planned ignitions, we have no requirement that emergency resources be available before the project can continue. Our assumption has always been that the project will come to successful completion without the need for emergency assistance. However, a project is required to have the necessary resources available to prevent an emergency from occurring in the first place.

Contingency action has been defined earlier as the action taken to suppress the prescribed natural



fire if it becomes a wildfire. Basically, it is equivalent to preplanned initial attack on a wildfire. Contingency action is, conceptually, the action necessary to prevent an emergency from occurring. Prescribed fire management is clearly the responsibility of the local line officer. Our planned ignition program requires no reliance on outside help. Local line officers should be expected to field contingency actions should they need to, but, if contingency actions fail, emergency fire suppression resources would be available from other sources as back up to the contingency action. Apparently though, in some prescribed natural fire programs, we have elevated the burden of contingency implementation to the Region, or, neighboring forests, who would have to supply the firefighting resources if available.

The consideration of resource availability requires that consideration be given to contingency planning. Without a definition of the resources needed (contingency plan), it is impossible to determine if the necessary resources are available. Therefore, contingency plans must be developed if resource availability is a decision criterion.

There is yet another important resources availability question. Equally important is the availability of resources to manage the prescribed natural fire operation itself. If commitments cannot be made for the appropriate level of resources to manage the prescribed natural fire there is no point in trying to do so.

Contingency resources levels, and to some extent, management resource levels, change over the duration of the prescribed natural fire. What may be a very simple contingency action early in the prescribed natural fire's history, may become a much more sophisticated need later on. It is very difficult to estimate the potentially sophisticated needs, especially at the initial prescribed natural fire decision point. It is even more difficult to assure their commitment to the fire.

There is a lot of concern about requiring these contingency resources to be locally available. It is believed that the local manager cannot supply these resources, nor commit them, on many prescribed natural fires. Thus, we find the current criterion attempts to force Regional availability and commitment of resources to the prescribed natural fire.

There should be mechanisms for negotiating contingency resources from a higher organizational level. If resources aren't locally available, it would be appropriate for the local manager to negotiate availability with the Region for resource commitment to the project (prescribed natural fire). This occurs in many other special project areas, such as, fire rehabilitation, forest pest projects, and even large planned ignitions.

Once again, the main quandary is the uncertainty of quantity over time. If a Region agrees to provide resource support, when will they need to provide it, and for how long? Also, the Region must analyze the cost of this decision. Not the economic cost, but rather the opportunity cost. The commitment of resources naturally precludes the resources from being available for emergency use elsewhere. What is the cost?

Decisions to tie up resources for extended periods clearly affects the total mobility of the fire system Regionally, and potentially, Nationally. Yellowstone was a perfect example. Early in the 1988 fire season many wildfires in other parts of the country were begging for resources which were assigned to prescribed natural fires in Yellowstone. The loss of wildfire suppression efficiency associated with the prescribed natural fire decisions in Yellowstone will never be known, but there are some strong feelings, especially by our cooperators (States), that the sacrifice was high.

The inventory of fire fighting resources has evolved to meet the emergency demand. Prescribed natural fires threaten to reduce inventory levels below the minimums necessary by placing a larger

demand on the inventory.

In 1988, the nation apparently ran out of hand crews. Several locations around the country were asked to train additional fire crews, and, we employed the Army in Yellowstone. Hand crews that were assigned to prescribed natural fires during this period would have been assigned to wildfires. The inventory of hand crews was drawn to zero and additional supply had to be obtained.

Some feel that escaped prescribed natural fires should not draw the inventory levels below minimums necessary for other wildfire emergencies. That is, some feel that escaped prescribed natural fires could be prevented by not allowing them to occur in the first place.

Regions will have to decide minimum stocking levels for their emergency fire fighting resources, guided by National mobility needs. The Regional decision to commit resources to prescribed natural fires must be made after a Regional risk assessment is undertaken for the decision.

The decision flow for these resource availability questions is discussed below. Figure 6 illustrates the decision tree. The decision is initiated by the local manager. The initial question posed here should not be, "Are resources available elsewhere to help me manage this fire," but rather, "Are we (the decision maker) able to help ourselves?"

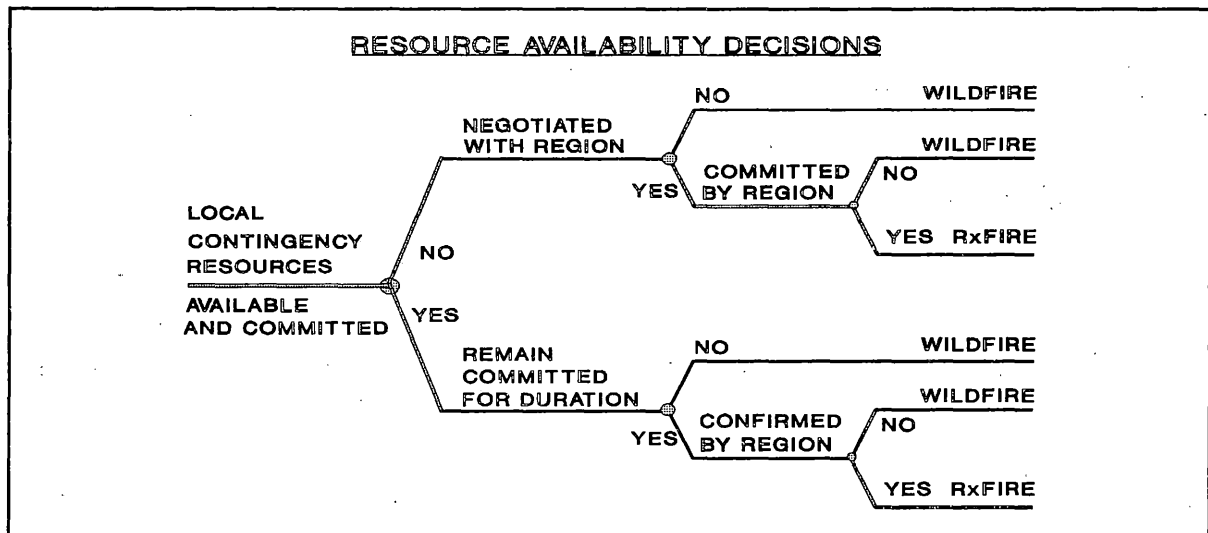


Figure 6

The Forest Supervisor should ask the question, "Do I have the resources necessary to implement my contingency plan on this prescribed fire?" If the answer is no, then negotiations with the Region can be undertaken. If the answer is yes, then we have another problem.

If local resources are available to implement the contingency action necessary, the attendant question then is, "Can I, or do I want to, maintain my contingency capability throughout the life of the prescribed fire?" If the answer is no, then a wildfire can be declared, or, negotiation with the Region for commitments might be undertaken.

There is, however, Regional impact if the decision is to maintain the capability to implement a

contingency action. It is at this point that the Region should have oversight authority for the decision.

The oversight question at the Regional level is a tradeoff question, "Can we afford to have these resources unavailable to us for the remainder of the fire season?" Currently, the Regional Preparedness Level (Region Six) is used to help make this decision. Perhaps some refinement in this concept will alleviate the real conflict between a local decision affecting Regional mobility and the Regional need.

This is not a well defined area. The resources identified in the contingency action are managed by a national forest. Is their Regional and National mobility under local control, or Regional control? Certainly those shared resources committed to the contingency are under Regional and National control, but what about local resources? Will we be in dire need for a Division Supervisor or two that could easily have come from the forest managing an prescribed natural fire? The concept of total mobility needs better definition. It also needs complete commitment by the line officers in the organization.

If the local manager doesn't have the resources available then negotiations with the Region may proceed. The Region must decide if the resources are available and if they can be committed for the duration of the project. If the answers are yes, a prescribed natural fire may be allowed. Otherwise, a wildfire will have to be declared.

The concepts discussed here are also applicable to any resources necessary for the successful completion of the project. In addition to resources necessary to implement a contingency plan, resources are necessary to conduct the project. Such items as monitoring personnel and equipment, line officer and staff availability, and funding, all follow the same concepts. Decisions should be made about their availability now, and for the life of the project, before the decision to implement and prescribed natural fire is made.

Smoke Dispersion and Effect

Smoke dispersion models are unavailable for common use at this time. Any estimate of smoke dispersion is a subjective estimate. Our knowledge of smoke's potential impact is quite limited and our ability to quantify it even less so.

There are three smoke management techniques that can be conceptually applied to the smoke generation problem from a prescribed fire, avoidance, dilution, and emission reduction.

Avoidance smoke management techniques attempt to avoid a problem by sending smoke away from any sensitive area. You actually time your prescribed fire to take advantage of meteorological events which allow you to avoid a problem. Obviously this technique has little applicability to the prescribed natural fire because these fires extend over long periods. Timing the activity is not within our control.

Dilution smoke management is generally accomplished by burning under conditions of higher wind speeds where the particulates emitted are scattered throughout a larger volume of air thus diluting concentrations. Due to the duration of prescribed natural fires successful dilution is a function of mother nature and not of our ability to control the situation.

Emissions reduction smoke management techniques call for changing burning prescriptions to allow fuel consumption under fuel moisture conditions which actually reduce emission production. Typically, this means more efficient combustion, thus more available fuel, and thus more intense fire behavior. This technique, if applied, would force prescriptions toward drier conditions. Smoldering combustion, after passage of the active flaming zone, produces the most emissions. So fuel moistures must be specified so that total emissions are reduced and not simply emissions from any particular period of

the burn. Emission reduction applicability to prescribed natural fires has the same limitations as other techniques, over time things change and we can't control them.

So, our current techniques to manage smoke cannot effectively be applied to prescribed natural fires because we are unable to time our activity, and, because the activity occurs over an extended period of time. In short, we have no control over the smoke. Therefore, if a problem is anticipated the fire should be declared a wildfire.

State smoke management plans usually exclude wildfire smoke from their provisions. Smoke from prescribed fires is usually subject to the plan provisions. Smoke from prescribed natural fires, conceptually, is no different than smoke from planned ignitions. With our inability to control smoke from prescribed natural fires we run a greater risk of violating State smoke management plans. There may be, however, opportunities to request waivers from these provisions for prescribed natural fires.

Recurrent Validation Using Actual Fire Conditions

The idea of recurrent validation is prevalent in all existing prescribed fire plans and is, in fact, inherent in the fire management policy of the Forest Service. Prescribed fire managers are required to determine periodically if the fire is within prescription according to policy.

The idea of using recurrent validation as a decision criteria, or better said, in place of decision criteria, has already been mentioned. It seems inappropriate to substitute recurrent validation for our inability to forecast events because it leads to uninformed decisions. It is appropriate to validate your situation on a recurrent basis.

It is also appropriate to consider, as a decision criterion, your capability to validate the situation on a recurrent basis. This is not unlike the Resource Availability questions raised earlier. What you are asking is, "Are the capabilities available to me to provide recurrent validation?" and if so, "Can I maintain that capability through the life of the fire?" Inherent in this decision is maintaining the skill levels required to help you with recurrent validation. So, as a decision criterion, we see no difference between this question, and the resource availability question. It is simply another kind of resource necessary for the successful implementation of the prescribed natural fire.

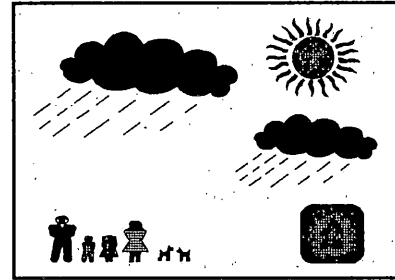
The fire management policy requires the manager to be aware of current conditions influencing the prescribed fire so a decision can be made with respect escaped prescribed fire. The amount of recurrent validation should be determined by this need. Daily validation may suffice at one point in the life of the burn, whereas, later in a fire season more frequent validation may be required.

In addition, the definition of an escaped prescribed fire might need some clarification. Consider that fire behavior varies tremendously over any single 24 hour period. What is unacceptable fire behavior at 15:00 hours may very well turn into acceptable fire conditions at 03:00 hours. Currently, there is no time considerations in the definition of an escaped prescribed fire, in fact, a definition is not found anywhere. This makes one question whether the traditional prescription elements of flame length, rate of spread, and environmental elements that create them, are appropriate for the prescribed natural fire decisions. These traditional prescription elements might better be employed in the initial program desirability question. At that level, these elements could combine to preclude a program of prescribed natural fires at specific times of the year where fire behavior is anticipated to cause unwanted effects. They could, theoretically, preclude a program entirely if the effects were always detrimental.

Perhaps better prescription elements are in the form of critical values as mentioned under fire behavior/fire perimeter estimation. The use of critical values as prescription elements, and the violation of them as the decision point, greatly simplifies the recurrent validation problem.

Drought Indicators/Predictions

One severe short coming of our decision criteria in 1988 was the obvious lack of any drought indicator in most decisions. The Report on Fire Policy (Philpot et al, 1988) covers this point in depth. It should be noted here that there are places where drought may not be of significant concern, such as the more arid places where these fires might be allowed to burn. But, over most of the country drought has a significant influence on fire behavior.



Currently there are at least two popular drought indexes, the Palmer Drought Index (Keetch and Byram, 1968) used for agriculture, and the Keetch-Byram Drought Index incorporated in the 1988 revision of the National Fire Danger Rating System. The Palmer Drought Index (PDI) seems to have the greatest use and exposure.

Similarly, the Keetch-Byram Drought Index for the same locations in Yellowstone clearly showed a drought condition exceeding by a significant amount the previous worst case encountered in 1981. The Southeastern Region uses the Keetch-Byram Drought Index as their Cumulative Severity Indicator for a fire season with good success.

The Palmer Drought Index has been in use for an extended period and is readily available. In some parts of the country records prevail in the 1930's (severe drought conditions). The PDI has another useful feature, it predicts the probability that a drought will end. The PDI system uses climatological probabilities from its extensive historical basis to estimate probabilities of staying in the existing condition, changing for the better, or, changing for the worse. These probabilities can, and should, be used to make judgments about potential fire season severity.

The PDI and Keetch-Byram Index are appropriate for long term drought conditions. They are designed to represent the drought associated with longer climatological events, for example, from one fire season to the next. Within any particular fire season drought is well represented by at least two NFDRS components, Energy Release Component and the 1000 HR fuel moisture estimate.

Energy Release Component (ERC) from the National Fire Danger Rating System (NFDRS) can be used as an indicator of seasonal severity. Typically ERC is plotted as the season progresses against previous historical highs. The seasonal trace for ERC in selected locations in Yellowstone NP clearly indicate that the 1988 season exceeds the previous "worst" season (1981) by a large amount. These seasonal traces can be used to compare current conditions with historical conditions and judgments made as a result.

The 1000 HR fuel moisture was added to the 1978 update of NFDRS specifically for the purposes of representing drought conditions over a fire season. It is a useful indicator of current dryness within any particular fire season and at any particular time.

Gross Acreage Limitations

Many plans stipulate a maximum acreage per year, or per event, that can be allowed. These limits are difficult to derive factually where these are attempts to limit the extent of a problem. In some instances it can be shown that these limits have actually led to uneconomic decisions because the limits place an artificial constraint on the line officer. Once a prescribed natural fire exceeds these arbitrary limits

a wildfire must be declared, regardless of the effects being produced by the prescribed natural fire. Generally speaking, the simple consideration of fire size is not an issue, but rather, what is impacted because of that fire size.

In some cases acreage limits are designed to emulate mother nature's "natural" regime for an area. Forest Service policy is designed to allow mother nature to define the natural role in the future, rather than having the Forest Service replicate the past. This precludes the use of acreage limits as a means to emulate mother nature's natural cycle.

Operationally, acreage limits may be of value. We use acreage limits in the planned ignition program by design. Acreage is one criterion which we use to decide if a fire has exceeded our logistical capability to manage. We could adopt a similar approach for prescribed natural fires. The important difference between operational use of acreage limits, and, use for avoiding a problem, is the aspect of effects. Operational acreage limits are used to define when a project ends, not when effects become unacceptable.

Multiple Fires

Multiple fires compound the potential for problems. The number of fires however, is not the main issue. The resources available to manage and implement contingency actions determine how many fires can be allowed to occur. Thus, resource availability, and the decisions discussed in that section, are applicable to the multiple fire question. If sufficient resources are not available or can't be committed, no more fires can be allowed to occur.

Off-Site Environmental Effects

Environmental effects from fire are difficult to predict with any certainty. Usually, effects are estimated qualitatively by resource specialists. The further removed the effect is from the problem (the fire) the more difficult the prediction becomes, and the less certain the result.

In addition, control techniques and mitigating measures are limited for most effects mechanisms. It is very difficult to mitigate water quality impacts, smoke effects, or other off-site impacts.

For these reasons, consideration of off-site environmental effects becomes a critical constraint to the decision. If unacceptable off-site effects are anticipated, the wildfire decision should be made, thus avoiding a problem altogether. It may be most appropriate to consider these aspects in the program decision rather than the project decision.

Funding

Prescribed fires are paid for by the benefitting function. Funding is a go-no go decision criterion on any prescribed fire. If sufficient money is not available to fund the entire project then the project shouldn't be undertaken. A wildfire course of action is necessary in these cases.

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